B I D D I N G D O C U M E N T

For

Procurement of EPC Contract

For

Construction of Inter-modal IWT Terminal at Kalughat, Bihar

VOLUME–2

TECHNICAL SPECIFICATIONS AND DRAWINGS

NCB No: CANW-1/IWAI/JMV/

Employer: Inland Waterways Authority of India, Ministry of Shipping, Government of India

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TABLE OF CONTENTS

1 GENERAL INFORMATION AND EMPLOYER'S REQUIREMENTS / SCOPE OF WORK 9

1.2 GENERAL INFORMATION 9

1.2.1 Background 9

1.2.2 Site Location 9

1.2.3 Site Information 10

1.3 EMPLOYER'S REQUIREMENTS 13

1.3.1 General 13

1.3.2 Site Grading 13

1.3.3 Berthing Structures including all associated facilities and Approach Trestles 14

1.3.4 Bank Protection Works 15

1.3.5 Stockyard Development 15

1.3.6 Buildings 15

1.3.7 Internal Roads 16

1.3.8 Vehicle Parking Area 16

1.3.9 Water Supply System 16

1.3.10 Storm Water Drainage System 17

1.3.11 Sewerage System & Waste Collection Center 17

1.3.12 Road Weigh Bridge 17

1.3.13 Gate House Complex , Boundary wall and Fencing 17

1.3.14 Electrical Works 17

1.3.15 Numerical Model Studies 23

1.3.16 Fire-fighting System 24

2 DESIGN CRITERIA 25

2.1 CIVIL 25

2.1.1 Codes and Standards 25

2.1.2 Design Life 26

2.1.3 Design Vessel Sizes 26

2.1.4 Berthing Structures and Approach Trestles 26

2.1.5 Discharge 28

2.1.6 Scour Depth 28

2.1.7 Load Combinations 29

2.1.8 Safety factors 29

2.1.9 Minimum Cover 29

2.1.10 Serviceability Criteria 29

2.1.11 Material Specification 29

2.1.12 Stone Pitching Works 31

2.1.13 Stockyard Development 31

2.1.14 Building Works 31

2.1.15 Internal Roads and Vehicle Parking Area 35

2.1.16 Storm Water Drainage System 36

2.1.17 Sewerage System 36

2.1.18 Water Supply System 36

2.2 ELECTRICAL 37

2.2.1 General 37

2.2.2 Errors, Omissions and discrepancies 37

2.2.3 Other Technical Requirements 37

2.2.4 Standards and Regulations 37

2.2.5 Earthing and Lightning Protection System 42

2.2.6 Lighting System 47

2.2.7 Switchgear 48

2.2.8 Cables 49

2.2.9 Cable Trays and Fittings 50

3 GENERAL REQUIREMENTS 52

3.1 SITE ACCEPTANCE AND MOBILIZATION/DEMOBILIZATION 52

3.1.1 Acceptance of Site 52
3.1.2 Mobilization 52
3.1.3 Demobilization 52
3.1.4 Access 52
3.1.5 Permits and Licenses 52
3.2 TEMPORARY WORKS 52
3.2.1 Utilities 52
3.2.2 Waste and Rubbish 53
3.2.3 First Aid and Fire Protection 53
3.2.4 Construction Safeguards 54
3.2.5 Protection of the Public 54
3.2.6 Contractor's Laboratory & Equipment 54
3.3 ENVIRONMENTAL PROTECTION 54
3.3.1 Fires 54
3.3.2 Disposal of Waste and Cleanliness 55
3.3.3 Drainage 55
3.3.4 Pollution Control 55
3.3.5 Environment 55
3.4 SUBMISSION OF DOCUMENTS DURING PROJECT EXECUTION 55
3.4.1 Programme of Works 55
3.4.2 Work Schedules, Survey Data & Drawings 55
3.4.3 Maintenance Plan 56
3.4.4 Weekly and Monthly Progress Reports 56
3.4.5 Design & Drawing Submissions 56
3.5 QUALITY CONTROL AND ASSURANCE 59
3.5.1 General 59
3.5.2 Improper Certification of Unsatisfactory Work 60
3.5.3 Quality Plan and Quality Procedures 60
3.5.4 Submission and Certification of Construction Documents 60
3.5.5 Certificates for Work Item Completion 60
3.5.6 Certificates for Activity Completion 61
3.6 FIELD SURVEYS AND INVESTIGATIONS 61
3.6.1 General 61
3.6.2 Setting Out 62
3.6.3 Topographic Surveys 62
3.6.4 Geotechnical Investigations 62
3.6.5 Post Construction Survey 62
3.7 EMPLOYER'S RESPONSIBILITIES 62
3.7.1 Datum Points and Levels 62
3.7.2 Contractor Working Area 62
4 SPECIFICATIONS – CIVIL 63
4.1 MATERIALS 63
4.1.1 General 63
4.1.2 Water 64
4.1.3 Aggregate 64
4.1.4 Sand 66
4.1.5 Cement 67
4.1.6 Steel 68
4.1.7 Bricks 70
4.1.8 Stones 71
4.1.9 Admixtures 71
4.1.10 Water Bars (Water Stops) 73
4.1.11 Bitumen/Bituminous Materials 73
4.1.12 PVC Pipes 74
4.1.13 Wood/Timber 74
4.1.14 Paint 74

4.1.15 Polysulphide Sealants 76
4.2 PLAIN AND REINFORCED CONCRETE WORKS 76
4.2.1 General 76
4.2.2 Materials 77
4.2.3 Grades of Concrete 77
4.2.4 Type of Concrete Mix 77
4.2.5 Concrete Mix Proportioning 77
4.2.6 Batching 80
4.2.7 Concrete Mixing 81
4.2.8 Transportation, Placing and Compaction 81
4.2.9 Construction Joints 84
4.2.10 Separation Joint 84
4.2.11 Expansion Joints/Isolation Joint 84
4.2.12 Water Stops 84
4.2.13 Protection of Freshly Laid Concrete 85
4.2.14 Curing 85
4.2.15 Field Tests 85
4.2.16 Inspection and Testing of Structures 89
4.2.17 Finishing of Concrete 89
4.2.18 Cement Wash 90
4.2.19 Form Work 90
4.2.20 Exposed Concrete Work 94
4.2.21 Concrete Underwater 97
4.2.22 Underground Concrete Work 97
4.2.23 Concreting in Inclement Weather 97
4.2.24 Grouting 97
4.2.25 Continuous Concreting 98
4.3 PILE FOUNDATIONS 98
4.3.1 General 98
4.3.2 Bored cast in-situ Piles 98
4.4 SITE GRADING 105
4.4.1 General 105
4.4.2 Material 106
4.4.3 Compaction 107
4.4.4 Disposal of Surplus Excavated Material 108
4.4.5 Acceptance of Works 108
4.5 INTERNAL ROAD WORKS 109
4.5.1 General 109
4.5.2 Granular Sub–Base 109
4.5.3 Cement Bound Material (CBM) 112
4.5.4 Concrete Block Paving 114
4.5.5 Removal of Surplus Earth 120
4.5.6 Brick Pitching 120
4.5.7 Traffic Markings 121
4.6 STORM WATER DRAINAGE 122
4.6.1 General 122
4.6.2 Scope 122
4.6.3 Materials 122
4.6.4 Execution 123
4.6.5 Inspection 124
4.6.6 Construction of Catch Basins and Trench Drains 124
4.6.7 Installation of Flap Gate 125
4.6.8 Rain Water Harvesting System 125
4.7 EARTHWORK 125
4.7.1 General 125
4.7.2 Nature of the Ground 125
4.7.3 Earthwork Method 125

4.7.4 Correct Widths and Depths of Excavations 125
4.7.5 Method of Excavation 125
4.7.6 Shoring Excavations 125
4.7.7 Staking 126
4.7.8 Filling & Backfilling Generally 126
4.7.9 Trimming of Slopes 127
4.7.10 Draining of Excavation 127
4.7.11 Existing Levels 128
4.7.12 Disposal of Surplus Excavated Material 128
4.7.13 Trench Excavation 128
4.7.14 Protection of Services 128
4.7.15 Trenches not to be Left Open 128
4.7.16 Polythene Sheeting 128
4.7.17 Anti-Termite Treatment 129
4.8 BRICK MASONRY WORKS 130
4.8.1 General 130
4.8.2 Materials 130
4.8.3 Construction Procedure 130
4.8.4 Jointing 132
4.8.5 Curing 133
4.8.6 Staging / Scaffolding 133
4.8.7 Embedment of Fixtures 134
4.8.8 Compressible Joint Fillers 134
4.8.9 Polysulphide Sealant for Joints 134
4.8.10 Galvanised Mild Steel Butterfly Wall Ties 134
4.9 BANK PROTECTION WORK 134
4.9.1 Preparation of Formation 134
4.9.2 Laying of Geotextile 134
4.9.3 Laying of Stone Pitching 135
4.9.4 Laying of Stone Pitching under water 136
4.10 CONTAINER STOCKYARD 137
4.11 STRUCTURAL STEEL WORK 137
4.11.1 General 137
4.11.2 Structural Steel 138
4.11.3 Quality Control 140
4.11.4 Fabrication 141
4.11.5 Welding 141
4.11.6 Galvanising 141
4.11.7 Installation 141
4.11.8 Bolting 142
4.11.9 Shop Painting 142
4.11.10 Inspection & Testing 142
4.12 STEEL/ALUMINIUM DOORS, WINDOWS AND VENTILATORS 142
4.12.1 General 142
4.12.2 Pressed Steel Door/Window/Ventilator Frame 143
4.12.3 Pressed Steel Door Shutter 143
4.12.4 Steel Windows & Ventilator 144
4.12.5 Rolling Shutters 145
4.12.6 Aluminium Glazed Doors/Windows/Ventilators 146
4.13 STEEL SHEET ROOFING AND SIDING 148
4.13.1 General 148
4.13.2 Materials 148
4.13.3 Workmanship 149
4.14 WOOD WORK 151
4.14.1 General 151
4.14.2 Material 151
4.14.3 Wooden Door / Window Frame 152

4.15 ROOFING TREATMENT 157
4.15.1 General 157
4.15.2 Material 157
4.15.3 Workmanship 157
4.15.4 Guarantee 158
4.16 PLASTERING AND POINTING 158
4.16.1 General 158
4.16.2 Materials 158
4.16.3 Cement Mortar with Waterproofing Compound 158
4.16.4 Workmanship 158
4.16.5 Plain Cement Plaster 159
4.16.6 Sand Face Plaster 160
4.16.7 Exposed Aggregate Finish Plaster 160
4.16.8 Pointing 161
4.17 FLOOR FINISHING 162
4.17.1 General 162
4.17.2 Cement Concrete Flooring General 163
4.17.3 Cement Concrete Granolithic Flooring 164
4.17.4 Heavy Duty Flooring 164
4.17.5 Precast Hydraulically Pressed Cement Tiles Flooring 165
4.17.6 Cement Plaster Skirting 166
4.17.7 Cast-In-Situ Terrazzo Flooring 166
4.17.8 Cast-In-Situ Terrazzo Skirting and Dados 168
4.17.9 Precast Hydraulically Pressed Terrazzo Tile Flooring 168
4.17.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado 168
4.17.11 Glazed Tiles Work 169
4.17.12 Glazed Tiles in Risers of Steps, Skirting and Dado 169
4.17.13 Kota Stone Flooring 170
4.17.14 Kota Stone in Risers of Steps, Skirting and Dado 170
4.17.15 Marble Stone Flooring 171
4.17.16 Marble Stone in Risers of Steps and Skirting 171
4.17.17 P.V.C. Flooring 171
4.17.18 Acid Resistant Tiles in Floors 172
4.17.19 Epoxy Floor Coating 173
4.18 PAINTING 173
4.18.1 General 173
4.18.2 White Washing 174
4.18.3 Colour Washing 175
4.18.4 Dry Distempering 175
4.18.5 Oil Bound Distempering 176
4.18.6 Waterproof Cement Paint 177
4.18.7 Acrylic Emulsion Painting 178
4.18.8 Acrylic Copolymer Aggregate Finish 179
4.18.9 Painting to Woodwork 179
4.19 SANITARY AND PLUMBING WORKS (BUILDINGS) 181
4.19.1 General 181
4.19.2 Bye-Laws and Regulations 182
4.19.3 Fees and Permits 182
4.19.4 Completion Certificate 182
4.19.5 Maintenance During Defects Liability Period 183
4.19.6 Water Supply 183
4.19.7 Soil, Waste, Vent and Rain Water Pipes and Fittings 185
4.19.8 Sanitary Fixtures and Fittings 186
4.20 WATER SUPPLY AND DISTRIBUTION SYSTEM 190
4.20.1 General 190
4.20.2 Material 190
4.20.3 Execution 190

4.21 SEWERAGE COLLECTION & TRANSFER SYSTEM 192
4.21.1 General 192
4.21.2 Scope 192
4.21.3 Material 192
4.21.4 Execution 193
4.22 WASTE COLLECTION CENTER 197
4.23 MASONRY BOUNDARY WALL 197
4.23.1 General 197
4.23.2 Materials 197
4.23.3 Workmanship 197
4.23.4 Construction 197
4.23.5 Clean Up & Repair 198
4.24 BERTH APPURTENANCES 198
4.24.1 General 198
4.24.2 Fenders 198
4.24.3 Bollards 201
4.24.4 Ladders 205
4.24.5 Rubbing Strip 205
4.24.6 Edge Angles 205
4.24.7 Drain Holes 205
4.24.8 Mooring Rings 206
4.24.9 Expansion Joints 206
4.24.10 Painting And Galvenization specification 206
4.24.11 Information Technology Systems 207
5 SPECIFICATIONS – ELECTRICAL 208
5.1 ELECTRICAL EQUIPMENT 208
5.1.1 HT SWITCHGEAR 208
5.1.2 TRANSFORMERS 215
5.1.3 LT SWITCHGEAR 218
5.1.4 110V DC SYSTEM 228
5.1.5 Power and Control Cables 232
5.1.6 Lighting System 234
5.1.7 High Mast Lighting System 236
5.1.8 Cable Trays and Accessories 243
5.1.9 415 V DIESEL GENERATOR SET 245
5.1.10 Telephone System (EPABX) 249
5.1.11 List of Approved Makes 257
5.1.12 CCTV Surveillance System 259
5.1.13 Recommended Equipment/Component Vendor List 262
6 SPECIFICATIONS – MATERIAL HANDLING SYSTEM/ EQUIPMENTS 264
6.1 GENERAL 264
6.2 MECHANICAL EQUIPMENT 264
6.2.1 General 264
6.2.2 MOBILE HARBOUR CRANE (MHC) 264
6.2.3 SPREADER 266
6.2.4 REACH STACKERS 266
6.2.5 FLATBED TRAILOR TRUCKS 266
7 ROAD WEIGH BRIDGE 267
7.1 SPECIFICATION DATA SHEET - ROAD WEIGH BRIDGE 267
8 SPECIFICATIONS - FIRE FIGHTING SYSTEM 268
8.1 SCOPE OF WORK 268
8.2 MAIN TECHNICAL REQUIREMENTS 269
8.2.1 General 269
8.2.2 Design Creteria 269
8.2.3 Fire Water Tank and Pump House 270

8.2.4 Hydrant System 270
8.2.5 Fire Extinguisher 271
8.2.6 Selection of Pump capacity 271
8.2.7 Selection of Pump Head 272
8.3 FIRE DETECTION AND ALARM SYSTEM 272
8.3.1 Scope of work 272
8.3.2 Applicable Codes and Standards 272
8.3.3 Fire Alarm Panel 273
8.3.4 Analogue Addressable Fire Alarm System 273
8.3.5 Fire Detectors and Accessory 276
8.4 ELECTRICAL ASPECTS 281
8.4.1 Power Supply 281
8.4.2 Wires & Conduits 282
8.4.3 Junction Boxes 282
8.4.4 Grounding 282
8.4.5 Testing 282
8.4.6 Local Control Panel 282
8.4.7 Cables 284
8.4.8 Motors 284
8.4.9 Make of Components 287
9 DRAWINGS 288
9.1 LIST OF DRAWINGS 288

Appendices

Appendix A – Geotechnical Investigation Report

Appendix B – Environmental Management Plan

Appendix C – Form of Performance Guarantee for Anti-Termite Treatment

1 GENERAL INFORMATION AND EMPLOYER'S REQUIREMENTS / SCOPE OF WORK

1.2 GENERAL INFORMATION

1.2.1 Background

India has large number of inland waterways consisting of rivers, canals, backwaters, creeks, and lakes etc. which have the potential for development of efficient waterways transport network.

The Ganga – Bhagirathi - Hooghly river system from Haldia to Varanasi has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress.

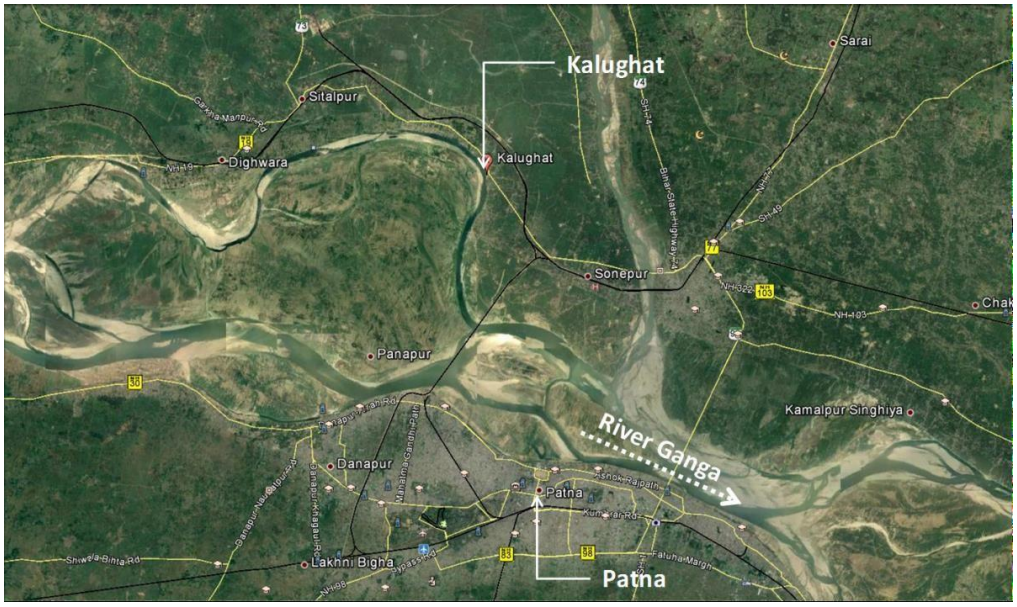
IWAI intends to develop an IWT terminal on National Waterway-1 at Kalughat in Bihar. The layout of IWT Terminal at Kalughat is shown in the **Drawing I-525/KGT/1001**.

This call for EPC bid being addressed to potential Contractors for the Engineering, Procurement of Materials & Construction of "IWT Terminal at Kalughat".

1.2.2 Site Location

The site is located on River Ganga at Latitude 25° 44' 25'' North and Longitude 85° 07' 12'' East, at Saran District in Bihar around 15 Kms of Aerial distance and around 25 Kms by Road from the Patna main city and Terminal is directly connected to NH19.

Location plan of the project site is shown below:



Location of Kalughat Intermodal IWT Terminal

1.2.3 Site Information

The site information included in the following paragraphs is only for the guidance of the Tenderers. The Tenderer shall conduct all necessary field tests and surveys to satisfy / verify himself regarding the correctness of the data furnished vis-à-vis actual condition. No claim whatsoever will be entertained for any variation between the actual site condition met with during the execution of the work and those indicated herein.

1.2.3.1 Rainfall

The rainfall data for Patna, near Kalughat is given below:

Rainfall Data for the Project Site

Month	Monthly Total (mm)	Number of Rainy Days	Heaviest Fall in 24 Hours (mm)	Year
January	12.2	1.3	51.8	1957
February	14.1	1.2	40.6	1949
March	9.4	0.7	36.7	1978
April	10.8	1.0	34	1983
May	38.1	2.7	59.6	1990
June	142.5	6.5	205.4	1997
July	381.0	14.9	250.8	1987
August	281.6	12.8	160	1948
September	229.3	10.2	273.5	1967
October	78.6	3.3	162.6	1946
November	8.7	0.6	65	1969
December	7.0	0.7	33	1995

***Source: IMD** (Available data of Patna is used for Kalughat)*

The number of rainy days varies from 1 to 15 in a month and heaviest rainfall varies in a range of 150-250 mm in a day.

1.2.3.2 Wind

The mean wind speed recorded by the observatory nearest to the project site is Patna which is found to be in the range of 1.0 m/s to 19.0 m/s. The basic wind speed at 10 m height for the project site is 47 m/s (169 km/h) as per IS 875 (Part 3).

1.2.3.3 Temperature

The highest and lowest temperature recorded at the Project Site are furnished below:

Maximum and Minimum Temperature at the Project Site

Month	Recorded Temperature (° C)			
	Mean Daily Maximum	Mean Daily Minimum	Highest Maximum	Lowest Minimum
January	30.0	16.2	22.4	1.1
February	35.1	18.9	26.0	3.4
March	41.4	24.4	32.2	8.2
April	44.6	29.8	37.0	13.3
May	45.6	31.8	37.4	17.7
June	46.6	31.7	36.4	19.3
July	41.2	29.5	33.0	21.1
August	39.7	29.3	32.9	20.5
September	37.5	28.8	32.5	19.0
October	37.2	26.7	31.9	12.0
November	34.1	21.9	29.0	7.7
December	30.5	19.7	24.5	2.2

1.2.3.4 Water Level

The proposed site at Kalughat is subjected to following water levels with reference to the mean sea level:

- High Flood Level: 52.50 m
- Low Water Level: 42.40 m

1.2.3.5 Current

The current in river Ganga at Kalughat varies from 0.50 m/s to 4.50 m/s.

The movements of floating crafts during construction shall be influenced by available draft, current, dimensions of craft, width of channel, etc.

1.2.3.6 Topographic Information

The topographical survey of the proposed terminal at Kalughat was carried out in June 2016. The area behind the river bank is relatively plain and levels are found to vary from +43.0 m to +52.0 m with respect to mean sea level. The topographic details are shown in the **Drawing I-525/KGT/1002.** The survey is only for the information of the Tenderer.

1.2.3.7 Hydrographic Information

The hydrographic survey of river Ganga near the proposed terminal at Kalughat was carried out in August 2015 and details is shown in **Drawing I-525/KGT/1003.**

1.2.3.8 Geotechnical Information

The geotechnical investigations at the proposed terminal location were carried out by M/s Pioneer Surveyors Ltd. The investigations included carrying out three boreholes in river and nine boreholes on land. The location of boreholes is shown in the **Drawing I-525/KGT/1004**. The investigation report is enclosed as **Annexure-1** for reference.

Note: The investigations report is only for the information of the Tenderer. Confirmatory boring shall be conducted by the EPC Contractor at various locations as per requirement. In case of any variation in soil strata from what has been provided in tender documents, no claim for compensation shall be entertained.

1.3 EMPLOYER'S REQUIREMENTS

1.3.1 General

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials and Construction / installation of all the items listed below, along with associated works as outlined in this tender document. For this purpose, the Tenderer shall conduct all necessary field tests and surveys to satisfy / verify himself regarding the correctness of the data furnished vis-à-vis actual condition. No claim whatsoever will be entertained for any variation between the actual site condition met with during the execution of the work and those indicated herein.

The broad items of works covered are listed below:

- Site grading
- Berthing Structures including all associated facilities
- Approach trestles connecting the berth with river bank
- Bank protection works
- Stockyard development
- Buildings with rain water harvesting system viz. Terminal Administration building, Worker's Amenity Building , Weigh Bridge control cabin & security office building with toilet block, Electrical Substation
- Toilet block
- Internal Roads
- Vehicle parking area
- Water supply system including Overhead Water Tank & Underground Reservoir
- Storm water drainage system with dump pond
- Sewerage system & Waste Collection Centre
- Gate House Complex , Boundary wall and fencing
- Electrical works
- Road Weigh Bridge
- Fire-fighting system
- Communication & IT
- Numerical Model Studies
- Environmental Management Plan

1.3.2 Site Grading

The Contractor shall first clear the area assigned for development from any obstructions or old structures and carry out a detailed topographic survey of the whole area. Formation level

shall be such that there shall be no flooding of the site. It shall be the responsibility of bidder to collect the existing details / type of structures with its foundation details and number of trees with girth size.

It is proposed to provide the formation level of +53.00m MSL within the terminal, up to the boundary wall of the terminal, stockyard, parking and road area & locations where buildings have to be constructed.

1.3.3 Berthing Structures including all associated facilities and Approach Trestles

i) There shall be a single jetty of 125 m length x 30 m width with suitable expansion joints as per relevant IS code. The top level of deck shall be +53.70 m with respect to MSL.

The coordinates for the proposed Berth are given below:

- 25° 44' 25.53'' North, 85° 07' 9.48'' East
- 25° 44' 21.47'' North, 85° 07' 9.44'' East
- 25° 44' 24.86'' North, 85° 07' 10.57'' East
- 25° 44' 22.10'' North, 85° 07' 10.50'' East

ii) The jetty shall be connected to bank line by approach trestles of 60 m length x 10 m width at its both ends.

iii) The general arrangement of proposed jetty with trestles showing typical plan and section are presented in the **Drawing I-525/KGT/1005** and **I-521/KGT/1006**.

iv) While the location, alignment, length and minimum width of the jetty and trestles are frozen, the sections shown in the drawings are only indicative.

v) The jetty shall have all the required accessories/fixtures including but not limited to the following:

a. Fenders including all its ancillaries

b. Bollards

c. Mooring rings on berth face

d. Safety ladders

e. Handrails

f. Stainless steel rubbing strip confirming to codal provision for the protection of edges of berth from rubbing of mooring ropes

g. Drain pipes shall be embedded at regular intervals. The proposed jetty shall be provided with suitable slope to drain off storm water.

h. Galvanized iron edge angles at various locations including on the sides of openings/pits.

i. The cranes and other equipments are proposed to be tyre mounted and therefore, no provision has been made for mobilisation of crane mounted on rails on the jetty.

vi) The proposed jetty shall be designed for Mobile Harbour Crane loading.

vii) The jetty shall have utility trench/duct to carry pipe lines for fresh water, bunker supply, cables etc., and it shall run all along the berth. The trench covers shall be seated properly and shall be intact with the trench side walls.

The trench/duct shall be provided on land side of jetty having inside dimensions of 1000 mm x 1000 mm deep.

The successful bidder shall submit the drawing of the utility trench for approval of the Owner.

viii) The Contractor shall adhere to and honor the Conditions of the Contract in all respects.

ix) The Contractor while executing the Works shall observe/follow good industry practice, which however shall meet the Employer's Requirements.

x) The stainless steel rubbing strips confirming to codal provision may be used.

xi) The satisfactory arrangement for transferring personnel from berth to Vessel is in the scope of the Contractor.

1.3.4 Bank Protection Works

Bank protection works shall be carried out at the site to protect the river bank from erosion during floods. A length of 600 m behind the jetty shall be protected by the stone pitching works. The requirement of quantum of bank protection works shall be confirmed by contractor after carrying out mathematical model study for the same. The mathematical model studies are required to be carried out in Post tender stage.

The general arrangement of these works is shown in the **Drawing I-525/KGT/1007and** the details shown in drawing are indicative**.** Stability of the slopes shall be carried out in accordance with the Indian standards and guidelines.

1.3.5 Stockyard Development

The Contractor shall plan and develop proposed Stockyard to facilitate stockpiling of 4 fully loaded containers plus 1 empty container stacking load. The yard level shall be maintained at +53.00 m MSL within the extents shown in **Drawing I-525/KGT/1008**.

1.3.6 Buildings

The following buildings shall be constructed as part of this Contract:

S. No.	Building	Type	Total Built up Area (m^2)
1.	Terminal Administration building	Two storey building	390
2	Worker's Amenity building	Single storey building	108
3	Weigh Bridge control cabin & security office building with toilet	Single storey building	55
4	Electrical Substation	Two storey building	900
5	Security Office	Single storey building	25

Rain water harvesting system shall be provided for all the buildings in the terminal.

1.3.6.1 Terminal Administration Building

The Contractor shall plan, design and construct Terminal Administration building for the administration of the proposed IWT terminal, at the location identified in the layout.

Typical layout and elevations are shown in **Drawing I-521/KGT/1009** and **I-521/KGT/1010** respectively.

1.3.6.2 Worker's Amenity building

The Contractor shall plan, design and construct Worker's Amenity building at the location identified in the layout to handle entry and exit clearances of the Terminal. Typical layout and elevations are shown in **Drawing I-525/KGT/1011.**

1.3.6.3 Weigh Bridge control cabin & security office building with toilet

The Contractor shall plan, design and construct Weigh Bridge control room and secutiry office with Toilet facility at the location identified in the layout to handle entry and exit clearances of the Terminal. Typical layout and elevations are shown in **Drawing I-525/KGT/1013.**

1.3.6.4 Electrical Substation

The Contractor shall plan, design and construct electrical substation for the electrical distribution system of the proposed IWT terminal, at the location identified in the layout. Typical details are shown in **Drawing I-525/KGT/1015**.

1.3.6.5 Security Office

The Contractor shall plan, design and construct security office at the location identified in the layout to handle entry and exit clearances of the Terminal.
Typical layout and elevations are shown in **Drawing I-525/KGT/1012.**

1.3.7 Internal Roads

The Contractor shall plan, design and construct internal roads for Terminal and same shall be provided as per the layout shown in tender document drawings. Any culverts required at the crossing of the drains and drainage system shall be provided.

Details of Roads as planned have been provided herein below:

Carriageway Width	Length
10 m	750 m

Layout of Internal Road and Typical Cross-section are shown in **Drawing I-525/KGT/1016**.

1.3.8 Vehicle Parking Area

The Contractor shall plan, design and construct suitable paved area for vehicle parking as shown in **Drawing I-525/KGT/1001.**

1.3.9 Water Supply System

The Contractor shall do design, installation and commissioning of the complete water supply distribution system including underground reservoir and the supply of potable water to the buildings, bunkering to vessels and other terminal area as shown in **Drawing I-525/KGT/1017.**

The source of water supply shall be either State Govt. water supply or bore well of terminal area. The test results of ground water and surface water sample are furnished in geo-technical report in this Volume.

1.3.10 Storm Water Drainage System

The drainage system for carrying the storm water run-off shall be designed for rainfall intensity of 55 mm/hr at project site location based on iso-pluvial maps of India.
Layout for Drainage system is shown in **Drawing I-525/KGT/1018**.

1.3.11 Sewerage System & Waste Collection Center

The Contractor shall plan, design and construct complete sewerage system including laying of pipelines for collection of sewage from buildings to septic tank. The location of sewage treatment plant is shown in **Drawing I-525/KGT/1001**.

The Contractor shall plan, design and construct suitable paved area of size 3m x 3m for Waste Collection Center as shown in **Drawing I-525/KGT/1001.**

1.3.12 Road Weigh Bridge

The Contractor shall plan, design and construct Static, pit less, surface mounted electronic type weighbridge having 100 MT capacity Road weigh Bridge with fully functional control cabins with data indication and weighment recording facility for inward and outward cargo.

1.3.13 Gate House Complex , Boundary wall and Fencing

The Gate house complex shall be provided in the southern boundary of the terminal at the location shown in the overall layout. Typical details and dimensions of entry gate are shown **in Drawing I-525/KGT/1019.**

The Boundary wall with fencing shall be provided all around the project boundary excluding river side location. The details of boundary wall with fencing are shown in **Drawing I-525/KGT/1020**.

1.3.14 Electrical Works

1.3.14.1 Employer's Requirements

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Manufacturing/Procurement, Supply, Storage at site, Construction/installation, Testing, Commissioning & Handing over of all the items/systems listed, along with associated works as outlined in this tender. Brief list of Employer's requirements are as follows:

- Plan, design and construct one substation (SS) for the electrical distribution system at the location identified in the tender.
- Internal (Buildings) and External illumination including lighting fixtures, necessary poles and high masts, MCB boxes, accessories and hardware including civil works.
- The Contractor shall provide complete Electrical works for all equipment / buildings as required.
- Electrical and Control cabling from proposed SS to individual equipment / buildings.
- All Earthing and Lightning protection works.

- Associated Civil Works

The Contractor while executing the Works shall follow good industry practice, which however shall meet the Employer's Requirements. The Contractor shall adhere to and honour the Conditions of the Contract in all respects.

The specifications provided in the tender together with enclosed drawings outlines the functional requirements and the operating characteristics which the equipment must fulfil. Alternative technical features other than those specified may be acceptable subject to the approval of the Employer. In any case, the performance of the system / equipment delivered shall be guaranteed in every detail by the Contractor. Overall dimensions (boundary dimensions) and functional requirements as specified shall be strictly adhered to. The scope of work outlined below and quantities indicated are for overall understanding of the Works, and does not absolve the Contractor from successful commissioning and operation of the Works with best available latest technology. Any item/equipment not listed but required for completion of the Works shall be considered as included in the scope of the Contractor.

The Contractor shall be deemed to have examined the site and familiarized himself with all existing site conditions. He shall accept the Site in the existing condition at the time of award of the Contract.

1.3.14.2 Detailed Electrical Scope of Work

Power at 11kV shall be made available upto a DP (Double Pole) Structure adjacent or within the Project boundary by Bihar State Power Holding Company Ltd (BSPHCL).Beyond this DP structure, power shall be fed to the Metering cubicle of BSPHCL through buried 11kV cable by BSPHCL. DP structure shall also be provided by BSPHCL . 11kV cable from metering cubicle of BSPHCL to 11kV switchgear Incomer shall be in the scope of the EPC contractor. All the coordination work with BSPHCL will be in the scope of EPC Contractor. The fees of such activities as charged by Electricity Board will be paid directly by IWAI. Further Power distribution shall be as per the attached **Power Single Line Diagram I-525/KGT/1024.**

SLD attached with this tender is indicative, final Load List and corresponding final SLD shall be prepared by the Contractor during detailed engineering and obtain approval of the Engineer-in-charge before proceeding for manufacturing / procurement.

The particulars of power supply are as follows:

Receiving Voltage	11 KV $\pm$ 10%
Supply Voltage	415V $\pm$ 10%
Phase	11 KV - 3 PH 3 Wires 415V - 3 PH 4 Wires
Frequency	50 Hz $\pm$ 3%
Combined Voltage & Frequency Variation	10%
Fault level	To be verified based on the data from BSPHCL
System Earthing (415V)	Solidly Earthed

Control Circuits:	
Circuit Breaker Protection & Tripping Control System	110 V DC, 2 Wire grounded (Grounded here refers to either one (+ve or -ve) not both)
Control System:	
UPS System, Field Hooters	240 V ± 10%, AC, 50 HZ ± 3%, 1 Ph, 2 Wire

The detailed scope of electrical works is given below:

S. No.	DESCRIPTION	QTY.
1.	11kV Indoor Switchgear, Draw out type, VCB of rating 630 A, as per the attached SLD.	4Nos
2.	11kV Bus PT, as per the attached SLD.	1 No.
3.	11kV/433V, 500KVA, indoor Dry type Utility Transformers, having off circuit tapping of +/-10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories.	2 Nos.
4.	433V/415V, 250KVA, indoor Dry type Lighting Transformers, having off circuit tapping of +/-10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories.	1 No.
5.	415 V panels LT switchgear as per the attached SLD.	
	a) 415V PCC at Electrical Substation	1 No.
	b) 415V PDB at Electrical Substation	1 No.
	c) 415V MLDB at Electrical Substation	1 No.
	d) 415V Panel at Pump House	1 No.
6.	Distribution Boards 415 Volts, 3 Ph, 4 wires with suitable busbars for Lighting, and Auxiliary supplies in Electrical Substation, Terminal Admin. Building, Pump House, Worker's Amenity Building, Security Office & Weigh Bridge Building etc.	Lot
7.	Substation Battery, Lead Acid (Valve regulated) Sealed Maintenance Free type, 110V DC with minimum 1 Hour back up, 110V DC battery charger with dual battery and battery charging cum DC Distribution boards at Electrical Substation.	1 Set
8.	415V Silent DG Set,175kVA at SS with AMF Panel and exhaust pipes as per pollution norms, including foundation.	1 Set

S. No.	DESCRIPTION	QTY.
9.	Industrial power sockets 240 V 15A, 2 Nos. at each floor in Electrical Substation, Terminal Admin. Building, Pump House, Worker's Amenity Building, Security Office, , Covered shed and as required for convenience at suitable locations.	Lot
10.	Welding socket 415 V TPN and earth 63A, 2 Nos. at each floor in Electrical Substation, Terminal Admin. Building, Pump House, Worker's Amenity Building, Security Office, Weigh Bridge Building, and as required for convenience at suitable locations.	Lot
11.	Exhaust Fans of suitable size in Electrical Substation, Worker's Amenity Building and Pump House for ventilation so as to remove heat generated by the Panels/Equipment.	Lot
12.	Internal illumination through LED fixtures and electrification including wiring & installation of fixtures, switches, sockets, fans, conduits, brackets, junction boxes, etc., in Electrical Substation, Terminal Admin. Building, Pump House, Worker's Amenity Building, Security Office & Weigh Bridge Building including peripheral lighting of buildings and structures.	Lot
13.	High Mast (30m) with LED Flood Light lamps as per the "High Mast & Cable Layout", **Drawing I-525/KGT/1022**.	04 Nos.
14.	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup in Electrical Substation, Pump House, Terminal Admin Building, Worker's Amenity Building etc., to ensure minimum 10 Lux in all the buildings, , all exit / entry points etc.	Lot
15.	Air conditioning of Terminal Administration Building including Control Room through centralized AC system to ensure maximum temperature of $27^{O}C$.	Lot
16.	Cables	Lot
	a) 11kV (UE), Heavy Duty, Armoured Cable, FRLS, XLPE, stranded Aluminium Conductor and Accessories	
	b) 1.1 KV, Heavy Duty, Armoured, Power Cables, FRLS, stranded Aluminium / Copper Conductor and Accessories.	
	c) 1.1 KV, Lighting Wires, PVC Insulated, FRLS, Stranded Copper Conductor and Accessories.	
17.	FRP Cable Tray with all accessories, mounting hardware, support structures, Cable risers, cable racks etc.	Lot

S. No.	DESCRIPTION	QTY.
18.	a) Cable terminations including cable termination kits, cable lugs, glands etc. for 11kV (E) grade cables	Lot
	b) Straight through Cable Joints. for 11kV (E) grade cables	Lot
	c) Cable terminations including cable lugs, glands etc. for 1.1kV grade cables for power, lighting and auxiliaries	Lot
	d) Straight through Cable Joints for 1.1kV grade cables for power, lighting and auxiliaries	Lot
19.	Earthing Protection System with Materials:	
	a) Earthing of HT, LT Equipment, Transformers, Generators, Panels, Distribution Boards, Motors, Junction Boxes and all equipment, lighting and power distribution network within the scope	Lot
	b) Main Earthing grid in the electrical substation and overall project area	Lot
20.	Lightning Protection for all buildings and structures within the scope as per IS:2309 comprising lightning finials, GI Strips for Horizontal and vertical conductors for Lightning protection, Earth pits with Test links for Lightning protection	Lot
21.	Excavation and backfilling of soil, sand cushion, protection bricks for buried cables wherever buried cables are taken	Lot
22.	Communication System comprising of EPABX of 25 Lines with Telephone Instruments as per the requirement of Phase-1	Lot
23.	Electrical Sub-station Safety Equipment	Lot
	a) CO2 type Fire extinguisher of 1 gallon capacity, each mounted on wheeled portable trolley	
	b) Sand buckets (4 nos) filled with sand alongwith required stand	
	c) Caution Board (11 KV & 415 V) and shock treatment chart	
	d) 900mm wide 12mm thick rubber mat (Electrical grade) in front of panels	
	e) First Aid box	
	f) 11kV Safety gloves	
	g) Discharge earthing rod for 11kV rating	

S. No.	DESCRIPTION	QTY.
24.	Special maintenance tools & tackles like	Lot
	a) Earthing trucks of each type in electrical substation	
	b) CB Racking handles of each type in electrical substation	
	c) Spring Charging handle of each type in electrical substation	
	d) Any other item as per recommendation of manufacturer of equipment	
25.	Any other item not included above but required for completion	

Note: The above quantities are indicative only.

1.3.14.1 Civil

Sl.No.	ITEM DESCRIPTION	Qty.
1.	At Electrical Substation Building Complete construction of Electrical Substation building including design, preparation of construction drawings and interior power and lighting as per the **"Substation Equipment Layout"**, **I-525/KGT/1015.**	Lot
2.	Cable trenches etc.	Lot
3.	Supports and foundations of lighting poles, DP structure, high masts, transformers etc.	Lot
4.	Cut outs on walls for taking cables, drilling & fixing of fasteners for fixing of fixtures/cables/conduits etc.	Lot

1.3.14.2 Miscellaneous/General Works/Services

1.	Mobilisation of all resources including Construction Machinery / Tools & Tackles / Welding Sets / Cranes / DG Set etc. for expeditious construction / fabrication / erection / installation of the required System to ensure timely implementation of the Works**.**
2.	Contractor shall arrange & post sufficient number of skilled and experienced personnel at Site to ensure trouble free Installation, Erection, Construction, Operation and Handing over to the Employer.
3.	The Contractor's Scope of Work shall include development of land / construction of his site fabrication yard at area allocated to him by the Employer.
4.	Fabrication and Erection of all temporary structures, arrangement for temporary power and water supply etc. adequate site lighting arrangement, transport logistics at site etc.

5.	Supply of all consumables / materials / lubricants, hydraulic fluids, oil, etc. including fuel oil for DG set.
6.	Clean up at site of all debris and temporary structures on a daily basis and final clean up at the time of handing over of the plant.
7.	All electrical safety requirements during site fabrication, erection, testing and commissioning, including adequate earthing of erection machinery and equipment.
8.	Proper and safe storage / security of all equipment and materials at site in the areas designated by the Employer in line with the Customs Employer / Regulations, where applicable.
9.	Supply of Lubricants, Oil, etc. for Initial fill, flushing, cleaning, refill, topping up & maintenance of Material handling system till the Works is put into satisfactory and continuous commercial use and has been "Taken Over" by the Employer.
10.	Attending meetings at the office of the Employer/ Employer's Representative or site or at any other station that may be fixed by the Employer for planning, co-ordination, clarifications, review, discussions etc.
11.	Co-ordination with other contractors, if any, and supplying necessary engineering data / information to the Employer to ensure satisfactory installation of equipment / execution of works.
12.	Supply of necessary calibrated instruments for carrying out performance tests of Equipment.
13.	Complete lot of base plates, foundation bolts, inserts, embedment, clamps, nuts, washers etc. as required for the system.
14.	All necessary painting and corrosion protection. The painting and corrosion protection for the equipment and structures is included in Contractor's scope. The painting and corrosion protection shall be as per the specification furnished elsewhere. The painting scheme and the finish colour for all the equipment shall be as specified by the Employer after award of contract. Necessary finish paints including touch-up paints, if not applied at shop, should be supplied by the Contractor, in sealed containers for site application.

1.3.15 Numerical Model Studies

2D Model Studies shall be carried out to access the extent of scouring at the Kalughat Terminal and conclude the length required for bank protection work. If length arrived at by model studies differs from the length proposed in clause 1.3.4, the contractor shall implement the bank protection work based on length arrived at by model studies.

The model studies shall include the effects of overtopping of river discharge and construction of proposed berth and approach trestle on stability of bank.

This mathematical model study has to be carried out before the start of the construction works. The bidder shall engage agency for model studies with the approval of IWAI.

The Employer shall assist in issuing letters to concerned Govt departments for data available with them. Remaining data/information needed for the study shall be collected by the EPC Contractor.

1.3.16 Fire-fighting System

The Contractor shall do design, installation and commissioning of the complete fire-fighting system within the scope area including all the buildings.

Typical details of fire-fighting system are shown in **Drawing I-525/KGT/1023**.

2 DESIGN CRITERIA

2.1 CIVIL

2.1.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions and amendments. All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. It is well understood that when a brand name is given for a material, the Contractor has the right to propose any equivalent material of any other brand for approval of the Employer.

Indian Standards shall generally be followed. In case, any work or item is not covered by the Indian Standards, following standards shall be adopted in order of preference.

1. British Standards
2. American Standards
3. General Standards

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted. Codes and standards covering the major part of the works are included in the Tender Document and some of them are listed below:

IS 4651	Code of Practice for Planning and Design of Ports and Harbours
IS 1893	Criteria for Earthquake Resistant Design of Structures
IS 875	Code of Practice for Design Loads for Buildings and Structures – (Parts 1–5)
IS 456	Code of Practice for Plain and Reinforced Concrete
IS 800	Code of Practice for General Construction in Steel
IS 2911	Code of Practice for Design & Construction of Pile Foundations
IS 3370	Code of Practice for Concrete Structures for the Storage of Liquids
IRC 37	Guideline for the Design of Flexible Pavements
IS 13920	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces – Code of Practice
IS 4326	Earthquake Resistant Design & Construction of Buildings – Code of Practice
	National Building Code (2005)
IRC 58	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways
IRC 73	Geometric Design Standards for Rural Highways
IRC 112	Code of Practice for Concrete Road Bridges
BS 449	The use of Structural Steel in Building (Permissible Stress)
BS 648	Schedule of Weights and Building Materials
BS 5493	Protective Coating of Iron and Steel Structures against Corrosion
BS 5950	Structural Use of Steel work in Building (Limit State)
BS 6031	Earthworks
BS 6367	Code of Practice for Drainage of Roads and Paved Areas
BS 6399	Loading for Buildings
BS 8002	Earth Retaining Structures
BS 8004	Foundations
BS 8110	Structural Use of Concrete
BS 5930	Site Investigation
BS 8000	Foundations
MJ Tomlinson: Pile Design and Construction Practice	

2.1.2 Design Life

The permanent works shall be designed and constructed to give the following design lives:

- Jetty - 50 years
- Fenders - 08 years
- Bollards and ladders - 15 years
- Buildings - 50 years

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse.

2.1.3 Design Vessel Sizes

The least available depth (LAD) at Kalughat shall be 2.5m, the design vessel is considered as 3000 DWT but it shall be partially loaded up to maximum of 2000 DWT.

The design vessel size and characteristics to be considered for design of jetty are as follows:

Design Vessel Size (DWT)	LOA (m)	Beam (m)	Loaded Draft (m)
3,000 (partially loaded up to 2000 DWT)	**95**	**15**	**2**

However, 300 T to 3,000 T is the range of vessels anticipated at the jetty.

Sizes of those vessels are as follows:

- Length of the vessel = 60 to 95 m
- Width of the vessel = 9.5 to 15 m
- Moulded depth = 2.8 to 4 m
  Draft of the vessel = 1.2 to 2.5 m

The under keel clearance of 0.5m is to be maintained to firm up the design dredge level.

2.1.4 Berthing Structures and Approach Trestles

2.1.4.1 Loads

2.1.4.1.1 Dead Load

The dead loads shall be assessed based upon the volume of the material using the following densities:

- Plain Concrete : 2.40 T/m^3
- R.C.C. : 2.50 T/m^3
- Steel : 7.85 T/m^3
- Compacted Earth Fill : 1.80 T/m^3
- Water : 1.00 T/m^3

The unit weight of all other materials shall satisfy the requirements of IS:875.

2.1.4.1.2 Live Load

The live load to be considered on the deck of jetty includes the following loads

- Uniform distributed Live load of 3.5 T/m^2
- IRC class A/AA /70 R vehicle
- Loads due to mobile crane with a 45 T lifting capacity at 26 m maximum reach
- Stacking Load due to 20 ft or 40 ft length stacked as group up to 2 high and 2 across
- Load from othe container handling equipments such as Reach Stacker, Tractor and Rolled Trailers.

2.1.4.1.3 Berthing Load

- Berthing Energy

The design vessels are assumed to approach the berths under difficult berthing conditions at an angular approach of 20^o. Based on this criterion the approach velocity perpendicular to the berth has been calculated to arrive at the design berthing energy for various design vessels. The approach angle for berthing load calculations will be as per relevant IS codes.

Berthing loads are considered as per IS: 4651 Part III-1989. The Berthing energy calculated for 3,000 DWT vessel using IS: 4651 as per details below:

Dead Weight Tonnage (DWT)	3,000
Displacement Tonnage (DT)	3,990
Overall Length, LOA (m)	95
Beam Width, B (m)	15
Loaded Draft, d (m)	2.5
Berthing Velocity (m/s)	0.45
Approach angle (degree)	20^o

In view of manoeuvring / operation skill of barge operator in comparison to trained pilots of ships calling at ports, it is considered that berthing velocity of 0.45 m/sec is adequate. The berthing of vessels shall not take place during extreme condition i.e. H.F.L.

The design berthing energy works out to 59 Tm considering required safety factors.

2.1.4.1.4 Fendering System

Considering the water level variation of the order of 10.1 m between high flood level and low water level at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the vessel and the fender face is ensured at all water levels.

It is required to provide a suitable fender system, not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure below the limit of 50 T/m2.

Based on these criteria, the fender of SM 800, grade M 2 of Bridgestone make or equivalent has been proposed at each fender piles.

For the jetty, suitable type fenders of Bridgestone make or any other equivalent fenders shall be used and the berthing line shall be away from jetty face corresponding to the adopted fender.

2.1.4.1.5 Mooring Load

Mooring force of 30 T, as per Table-4, IS: 4651- Part III, shall be applied at any of the bollard location.

2.1.4.1.6 Current Load

The current loads on the structure shall be applied on the submerged parts of the structure as per IS: 4651 - Part III. The current velocity considered is as given below:

- Operation condition : 1 m/s
- Extreme condition : 4.50 m/s

2.1.4.1.7 Wind Load

The wind load on structure is considered as per IS: 875-Part 3. The basic wind speed (Vb) for operational and extreme condition shall be 17 m/s and 47 m/s respectively.

2.1.4.1.8 Temperature Load

- Daily maximum and minimum temperature difference is **+15°C**
- Coefficient of thermal expansion for RCC structure is taken as 11.7x10-6/°C.
- In temperature analysis, long term elastic modulus of the concrete is taken as half the instantaneous elastic modulus of the concrete.

2.1.4.1.9 Earthquake Load

Earthquake load shall be considered in design as applicable for the site as per IS 1893-2002.

The design horizontal seismic coefficient αh is calculated based on the following parameters:

- αh = Z I (Sa/g) / (2R), where
- Z = Zone factor = 0.24
- I = Importance factor = 1.5
- R = Response reduction factor = 3
- Sa/g = Average response acceleration coefficient, which depends on Time Period of the Structure The Time Period, T of the structure will be evaluated by STAAD Analysis considering Dead Load and 50% Live Load.

2.1.5 Discharge

Discharge of 30,000 cum/s shall be considered.

2.1.6 Scour Depth

Scour depth shall be considered suitably in compliance with IRC 78:2014 or Clause 110.1.3 of IRC 5. The width of the river at terminal location is calculated as per Lacey's equation. Slope of the river bed is 1:12,000 in main Ganga River. Slope near the terminal shall be measured from the hydrographic data.

2.1.7 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4): 2014 have been applied on the different components of the jetty.

2.1.8 Safety factors

Design of the marine piles shall be carried out in accordance with the recommendations given in IS 2911, IS 14593 and IRC 78. The following safety factors shall be used to establish the safe geotechnical working load capacities of the piles as given below:

End Bearing	SF = 2.5
Skin Friction on compression piles	SF = 2.5
Skin Friction on tension piles	SF = 3.0
Lateral Load	SF = 2.0

2.1.9 Minimum Cover

Clear cover to any reinforcement shall be as mentioned here under but shall not be less than the diameter of such reinforcement.

a) Pile : 75 mm

b) Top, bottom & side of footing (if any): 75 mm

c) Beams : 50 mm

d) Slab : 50 mm

2.1.10 Serviceability Criteria

→ **Deflection Limit**

The Deflection at the deck level is generally considered as H/350 in operating condition and H/250 in extreme condition. H is the distance from the average point of fixity to the top elevation of deck.

→ **Crack Width**

The crack width is calculated for service load combinations in accordance with IS:4651 (part 4)-2014.

2.1.11 Material Specification

The specifications are as given in this volume.

Structural Concrete	M-40
Leveling Concrete	M-15 of 100 mm thick. *The levelling concrete is considered as M15 grade 100 mm thick and this shall not be provided as wearing course over jetty deck slab.* ***M-40 grade wearing course of 75 mm average thickness shall be provided on the jetty and approach trestles.*** **And**

<table>
<tr><td></td><td><u>Minimum Reinforcement for the wearing course shall be 75 kg\m^3.</u></td></tr>
<tr><td>Reinforcement</td><td>Low alloy steel reinforcement of grade equivalent to Fe-500 D <u>in accordance with IS 1786</u>.</td></tr>
<tr><td>Cement</td><td>For plain and reinforced concrete works cement shall be of any of the following types:
1. 43 Grade OPC Ordinary Portland cement conforming to IS 269
2. Portland slag cement conforming to IS 455
3. Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)
4. Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)
For marine structures , the above mention types of cement shall also confirm to IS 4651 Part 4.
Chlorides in the concrete
Whenever there is chlorides in concrete there is an increased risk of corrosion of emb edded metal. The higher the chloride content or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, that is, cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below.
Limits of Chloride Content of Concrete
<table>
<tr><th>Sl. No</th><th>Type or Use of Concrete</th><th>Maximum Total Acid soluble Chloride Content Expressed as kg/m3 of Concrete</th></tr>
<tr><td>1</td><td>Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete</td><td>0.4</td></tr>
<tr><td>2</td><td>Reinforced concrete or plain concrete containing embedded metal</td><td>0.6</td></tr>
<tr><td>3</td><td>Concrete not containing embedded metal or any material requiring protection form chloride</td><td>3.0</td></tr>
</table>
</td></tr>
</table>

	The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Whenever possible the total chloride content of the concrete should be determined as per the approval of the Engineer-in-Charge. **Sulphates in concrete:** Sulphates are present in most cements and in some aggregates; excessive amounts of water –soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO3, should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix as per the approval of the Engineer-in-Charge. The 4 percent limit does not applied to concrete made with super sulphated cment complying with IS 6909 or as approved by the Engineer-in-Charge.
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm. This does not apply to Pile liner.
Protective coating to structural steel	Minimum DFT of 240 micron after sand blasting to SA 2.5 grade. **<u>However Protective coating is not required for Pile Liners.</u>**

2.1.12 Stone Pitching Works

Suitable stone pitching works shall be designed as per IRC 89 – 1997 and other necessary codal provision, to protect river bank along the jetty.

2.1.13 Stockyard Development

Stockyard shall be developed to allow container stacking for 4 fully loaded containers plus 1 empty container stacking load. Ground improvement, if necessary shall be carried out to achieve required bearing capacity.

2.1.14 Building Works

2.1.14.1 General

All civil & structural steel structures shall be designed satisfying the Codal provisions. Loading shall be as per IS:875 & IS:1893. The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, water distribution etc. Following minimum considerations shall be followed:

- Floor to floor height shall satisfy the bylaws of National Building Code.
- A 750 mm wide plinth protection shall be provided around each building.
- Finished floor level of buildings shall be 1000 mm above the finished ground level unless specified otherwise.
- All external walls shall be of 230 mm thick, all partition walls shall be minimum 115 mm thick with 1:4 cement mortar

All structures shall be analyzed as framed structure using STAAD.Pro for the loads and their combinations. However the design of the elements shall be carried out by either manually or standardized excel sheets or in house software packages or using STAAD.Pro software design module.

All designs of RCC structures shall be carried out as per IS 456. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristics strength and characteristic loads as per IS 456.

All underground RCC structures other than liquid retaining structures shall be designed as per IS: 456 cracked section with limiting crack width as per codal provisions. All Liquid Retaining Structures shall be designed as per IS:3370.

2.1.14.2 Foundations

Type of foundation system shall be decided based on loading arrangement, load intensity and soil strata. Design of foundation at various levels shall be dependent up on the soil profile, which in turn shall be as per recommendation of soil investigation report. All foundations shall be designed in accordance with relevant parts of IS:2974 and IS:456.

2.1.14.3 Loads

→ **Dead Load**

The unit weight of all other materials shall satisfy the requirements of IS:875.

→ **Live Load**

Live load shall be considered as given below and shall also satisfy the requirements of IS:875.

Flat Roof	150 kg/m2 + Dust load of 50 kg/m2 hanging load for pipe shall be considered as 100 Kg/m2 and 50 Kg/m2 for electrical, ventilation & air conditioning (wherever applicable)
Non-accessible roof	75 kg/m2 + Dust load of 50 kg/m2
Inclined roof	Roof slope upto 10 Deg: 75 Kg/m2 +50 Kg/m2 Roof slope above 10 Deg: [(75-(θ-10) x2] + 50 Subjected to a minimum of (40+50) =90 Kg/ m2 For sloping roofs with slope greater than 10°, members supporting the roof purlins, such as trusses, beams, girders etc may be designed for two-thirds of live load stated above
MCC Floor	300 kg/m2 +1.2T/m of Panel

→ **Seismic Load**

- Zone factor : Corresponding to seismic zone-IV
- Importance factor : 1.50
- Response reduction factor : 3 for RCC structures and 5 for Steel structure

→ **Equipment Load**

The Substation building shall be designed to accommodate anticipated static and dynamic loading from electrical equipment. Where the uniform floor live load adequately accounts for the equipment weight, the weight of such equipment as a dead load need not be considered.

→ **Impact Factor**

- For Manual monorail/Hoist design an impact factor of 1.20 shall be considered in design.
- For Electrical monorail/Hoist design an impact factor of 1.25 shall be considered in design.

2.1.14.4 Load Combinations

The load combinations shall be in accordance with IS:456, IS:800 and any other combinations as instructed by the Employer during detail engineering.

2.1.14.5 Minimum Cover

Clear cover to main reinforcement shall be as mentioned hereunder but shall not be less than the diameter of such reinforcement.

Pile	75 mm
Top, bottom & side of footing (if any):	50 mm
Pedestal / column - Below ground - Above ground	 50 mm 40 mm
Beams	25 mm
Slab	20 mm
Face of walls & grade beam	50 mm (in contact with soil)
Face of walls not exposed to soil	25 mm(min.) or dia of main bar
At each end of reinforcing bar	20 mm or twice the dia of bar whichever is greater
Columns of max. dimension 200mm or under and with longitudinal reinforcement diameter not exceeding 12mm	25 mm

2.1.14.6 Serviceability Checks

Crack width of all the structural elements shall be calculated wherever necessary as per IS:456.

2.1.14.7 Material Specification

The specifications are as given in this volume.

Structural Concrete	M-30
Leveling Concrete	M-10 of 100 mm thick
Reinforcement	Reinforcement bars shall be low alloy steel of grade Fe 500 D confirming to IS:1786.
Cement	For plain and reinforced concrete works cement shall be of any of the following types: 1. 43 Grade OPC Ordinary Portland cement conforming to IS 269

2. Portland slag cement conforming to IS 455
3. Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)
4. Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)

Chlorides in the concrete

Whenever there is chlorides in concrete there is an increased risk of corrosion of emb edded metal. The higher the chloride content or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, that is, cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below.

Limits of Chloride Content of Concrete

Sl. No	**Type or Use of Concrete**	**Maximum Total Acid soluble Chloride Content Expressed as kg/m3 of Concrete**
1	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
2	Reinforced concrete or plain concrete containing embedded metal	0.6
3	Concrete not containing embedded metal or any material requiring protection form chloride	3.0

The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Whenever possible the total chloride content of the concrete should be determined as per the approval of the Engineer-in-Charge.

Sulphates in concrete:

Sulphates are present in most cements and in some aggregates; excessive amounts of water –soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To

	prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO3, should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix as per the approval of the Engineer-in-Charge. The 4 percent limit does not applied to concrete made with super sulphated cment complying with IS 6909 or as approved by the Engineer-in-Charge. If Chloride & Sulphate content as per the soil investigation report done by contactor is found on the higher side, .S.R. cement is not suitable for use. It is better to follow recommendations of specialist Soil Investigating Agency in such cases and detailed guidelines given in IS 456 in this regard.
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm
Protective coating to structural steel	Minimum DFT of 240 micron after sand blasting to SA 2.5 grade.

2.1.14.8 Grade Slab

All ground floors shall be of R.C.C. (M-20) with minimum thickness of 150 mm over 75mm thick P.C.C. (M-10) base. Quantum of reinforcements to be used shall be 60 kg/m^3. The sub base shall be 230 thick Stone/bolder soling over compacted earth. The floor finish shall be 40mm thick including 13mm thick metallic hardener topping as per specification. Floor top shall be laid to slope minimum 1:100 towards floor drain for floor washing.

2.1.14.9 Drain

Drain shall be of RCC with natural slope towards collecting area.

2.1.14.10 Stair Case

- Minimum clear width (General / Fire escape) : 0.8m
- Tread width : not less than 250mm
- Riser : not greater than 180mm

Continuous Hand rail shall be provided.

2.1.15 Internal Roads and Vehicle Parking Area

Internal Roads and Vehicle Parking Area shall be designed with the provision of relevant IRC codes with the following minimum requirement:

Geometric Parameters:

- Maximum longitudinal grade : 3.0%
- Cross slope : Both direction 1.5% for All Roads
- Maximum super elevation : 5%
- Sight Distance : Intermediate sight distance

- Turning Radius at junction : Min. 25 m
- Design Speed : 80 km/hr

Pavement Design:

Traffic : 10 MSA

Specifications:

- Embankment : Min. density shall be 1.6 T/cum
- Sub grade : Min. CBR 8% and density 1.75 T/cum
- Granular Sub Base : Minimum 150 mm
- CBM Base : Minimum 200 mm
- Sand Bed : Minimum 30mm
- Surfacing : Paver Block

The culverts, if any, required for the cross drainage works shall be designed as per the IRC codes.

2.1.16 Storm Water Drainage System

Surface drainage shall be designed with the following basic consideration:

- The drainage system shall be planned to carry storm run-off from the proposed areas shown in the scope drawings.
- No allowance for sullage shall be kept.
- The storm water run-off shall be collected and stored for reuse using rain water harvesting.
- A maximum velocity of 2.5 m/s shall be allowed for RCC channel with lined surface.
- Manning coefficient for different pipe material shall be adopted as follows:
  - Concrete surface in good condition - 0.015
  - Masonry surface with cement plaster - 0.015

All pipes shall be RCC NP3 except below the road. Pipe shall be of NP4 type below road.

2.1.17 Sewerage System

The pipelines of suitable size shall be laid for collection of the sewage from the buildings to a septic tank followed by soak pit. The design and laying of the pipelines shall be carried out as per the provision of relevant IS codes.

2.1.18 Water Supply System

The capacity of the underground sump shall be 325 m^3 and the capacity of the overhead tank shall be 40 m^3.

The broad design parameters for water supply system are given below:

- Wastage and leakage in system: 15% of the total theoretical demand
- Hydraulic design of the pipeline shall be using Hazen-williams formula
- All pipelines shall be laid 1.2 m below ground

2.2 ELECTRICAL

2.2.1 General

The contractor shall work as per the drawings and designs described in the Tender document and the best current engineering practice. Particular attention should be paid to internal and external access to the electrical equipment in order to facilitate inspection, cleaning and maintenance. The contractor shall comply with latest code of practice published by the Bureau of Indian Standards as applicable. Care shall be taken so that materials and equipment supplied by contractor are the standard catalogued products of manufacturers regularly engaged in the manufacturer of such products and shall be of the latest standard designs that conform to the specific requirements.

a) The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.

b) All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.

c) The design shall comply with relevant codes and regulations listed.

d) All apparatus, equipment and works shall be so designed that they provide satisfactory service without any harmful effects for prolonged and continuous periods in the worst climatic conditions, stated hereinbefore.

e) The reference design ambient temperature for all electrical equipment shall be taken as $45^{O}C$ and appropriate de-rating factors shall be considered for equipment as applicable.

f) Suitable de-rating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.

2.2.2 Errors, Omissions and discrepancies

In case of errors, omissions and discrepancies between technical specification, schedules and drawings the following order shall prevail:

i) MOM with contractor in reverse chronological order.

ii) Technical specifications

iii) Tender drawings

iv) Schedule of Quantities

v) Bureau of Indian Standards

vi) International Standards

vii) In all case of doubt or omissions or discrepancies noticed in any item of work any drawing, the decision of the Engineer-in-Charge shall be final and binding on the contractor.

2.2.3 Other Technical Requirements

The contractor shall arrange all the instruments, materials and labour involved in setting out the works to the approval of the Engineer-in-Charge.

2.2.4 Standards and Regulations

The design and manufacture of the electrical equipment shall conform as a minimum to applicable codes, regulations and standards published by the following bodies:

BIS : Bureau of Indian Standards

IER : Indian Electricity Rules
BSI : British Standard Institution
ISO : International Organization for Standardization
IEC : International Electro-Technical Commission
IEEE : Institute of Electrical & Electronics Engineers
NFPA : National Fire Protection Association
NEC : National Electrical Code

Following is the list of some of the directly applicable Standards particular to the equipment. Any other relevant Indian Standard, not covered shall also be applicable.

STANDARDS	**TITLE**
IS:5	Colours for Ready Mix Paints and Enamels
IS:266	Specification for Sulphuric acid
IS:325-1996	Three phase Induction Motors-Specification
IS:375	Marking and arrangement of switchgear bus
IS:418	Tungsten filament lamps for domestic and similar general lighting purpose
IEEE:484	Recommended Design for Installation design and installation of large lead storage batteries for generating stations and substations.
IEEE:485	Sizing large lead storage batteries for generating stations and substations.
IS:694-2010	PVC Insulated Unsheathed and Sheathed Cables/Cords with rigid and Flexible Conductor for rated voltages upto and including 450/750 V
IS:732-1989	Code of practice for Electrical wiring installation
IS:900-1992	Code of practice for installation and maintenance of induction motors
IS:1231-1974	Dimensions of three phase foot mounted induction motors (4 Amendments)
IS:1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating
IS:1554-1988	PVC insulated (heavy duty) electric cables (Part I & II)
IS:1651	Stationary cells and batteries, Lead Acid Plate / Nickel cadmium (with tubular positive plates)
IS:1777	Industrial Luminaires with metal reflectors
IS:1944	Code of Practice for design of street lighting
IS:1947	Flood Lights

STANDARDS	TITLE
IS:2026	Power Transformers
IS:2206	Flame proof electric lighting fittings
IS:2215	Starters for fluorescent lamps
IS:2309-1989	Code of practice for protection and allied structures against lightning. (1 Amendment)
IS:2418	Tubular fluorescent lamps for general lighting services
IS:2705-1992	Current Transformer
IS:2713	Specification for Tubular Steel poles for Overhead Power Lines
IS:3043-1987	Code of practice for Earthing (2 Amendments)
IS:3156-1992	Voltage Transformers
IS:3231-1986, 1987	Electrical Relays for Power System Protection
IS:3427-1997	AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IS:3452-1966	Toggle Switches (3 Amendments)
IS:3528-1966	Waterproof electric lighting fittings
IS:3637-1966	Gas operated relay (1 Amendment)
IS:3639-1966	Fitting and Accessories for power transformers
IS:3646	Code of Practice for Interior Illumination
IS:3725-1966	Resistance wire, tapes and strips for heating elements (3 Amendments)
IS:3842-1966	Application guide for electrical relays for ac systems
IS:3895	Mono crystalline Semi-conductor rectifier cells and stacks
IS:3961-1967	Recommended current ratings for cables: Part 2 PVC insulated and PVC sheathed heavy duty cables (Part II-2 Amendments)
IS:3975-1999	Mild steel wires, strips and tapes for armouring cables
IS:4013	Dust-tight electric lighting fittings
IS:4029-2010	Guide for testing three phase induction motors

STANDARDS	TITLE
IS:4540	Mono – crystalline Semi-conductor rectifier assemblies and equipment
IS:4794-1986	Push Button Switches (Part 2)
IS:4889-1968	Methods of determination of efficiency of rotating electrical machines (2 Amendments)
IS:5082-1998	Wrought aluminium and aluminium alloy bars, rod, tubes and sections for electrical purposes (2 Amendments)
IS:5216-1986	Guide for safety procedure to practices in Electrical work
IS:5561-1970	Electrical power connectors
IS:5578-1984	Guide for marking of Insulated Conductors
IS:5831-1984	PVC insulation and sheath of electric cables (2 Amendments)
IS:6362-1995	Designation of methods of cooling for rotating electrical machines
IS:7098-1985	Cross linked polyethylene insulated PVC Sheathed cables
IS:7752-1975	Guide for improvement of power factor in consumer installation: Low and medium supply voltages
IS:7816-1975	Guide for testing insulation resistance of rotating machines
IS:8130-1984	Conductors for insulated electric cables and flexible cords
IS:8224	Electric Lighting fittings for Div.2 areas
IS:8623-1993	Low-Voltage Switchgear and Control gear Assemblies
IS:8789-1996	Values of performance characteristics for three phase induction motors
IS:9385-1983	High Voltage Fuse
IS:9537-1983	Conduits for electrical installations (2 Amendments)
IS:9583	Emergency Lighting units
IS:9792-1987	AC Electricity Meters
IS:9900	High-Pressure mercury vapour lamps
IS:9974-1981	High pressure Sodium Vapour Lamps (2 Amendments)
IS:10028-1981, 1985	Code of practice for selection, installation and maintenance of Transformers

STANDARDS	TITLE
IS:10118-1982	Code of practice for selection, installation and maintenance of switchgear and control gear
IS:10810	Methods of Tests for Cables
IS:11171-1985	Dry type Power Transformers
IS:11353-1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS:12021-1987	Control Transformers for Switchgear and Control gear for Voltages not Exceeding 1000 V ac
IS:12065-1987	Permissible limits of noise level for rotating electrical machines (1 Amendment)
IS:12075-2008	Mechanical Vibration of Rotating Electrical Machines with Shaft Heights 56 mm and Higher - Measurement, Evaluation and Limits of Vibration Severity
IS:12729-2004	Common High-Voltage Switchgear and Control gear Standards
IS:13118-1991	High Voltage alternating current circuit breakers
IS:13703-1993	Low-voltage fuses for voltages not exceeding 1000V AC or 1500 V DC (Part 2)
IS:13947-2004	Low voltage switchgear and control gear
IS:60034-5-2000	Rotating electrical machines : Part 5 Degrees of protection provided by the integral design of rotating electrical machines (IP CODE) - Classification
IS:60470-2000	High-Voltage Switchgear Alternating Current Contactors and Contactor-Based Motor Starters

In addition to Codes and standards, the installation works shall also conform to the requirements of following:

a) Indian Electricity Act

b) Fire insurance regulations

c) Regulations laid down by Chief Electrical Inspector of Bihar / CEA

d) Regulations laid down by the Factory Inspector

e) Regulations for the electrical equipment of Tariff Advisory committee

f) Any other regulations laid down by the Employer

g) Regulation of Pollution Control Board of Bihar

2.2.4.1 Standardization

Care shall be taken so that the materials and equipment are standard catalogued products of manufacturers regularly engaged in manufacture of such products and shall be of the latest standard designs conforming to specification requirements. Design shall also be based

on similar types of electrical equipment supplied from one manufacturer, utilizing interchangeable parts wherever practicable. Materials and equipment incorporated shall be of a type for which spare parts and replacements are readily available in India.

2.2.5 Earthing and Lightning Protection System

The complete earthing system shall conform to the provision of Indian Electricity Rules, and applicable code of practice for earthing IS: 3043, however for chemical earthing IEEE:80-2000 shall also be followed. Working layout drawings shall be prepared by the successful Contractor. Value of earth resistivity shall be considered as per the areas indicated in IS:3043 or the actual value as obtained from the site from previous records available with the employer, if any.

All Non-conducting structures shall be provided with Lightning protection consisting of Air termination network at the top and down conductors as per IS:2309. All Structures made of conducting material shall be protected by adequate earthing arrangements and air terminations at the top as per IS:2309. Conductors shall be Galvanized Iron (GI) of suitable size as per IS:2309. Buried lightning grid conductors of 75mm x 8mm size shall be provided for interconnection of the Lightning earth pits around individual building. The same shall also be connected with the main plant earth grid at places through isolating link installed in Earth pits.

2.2.5.1 Earthing Below Ground

a) The main earthing grid shall be buried below ground unless required otherwise. For crossing any trench or under-ground pipe minimum earth coverage of 500 mm shall be provided over the earthing conductor.

b) Where the earthing conductor passes through reinforcement or steel plate it shall be bonded to the same.

c) All building steels and columns shall be bonded directly to the earthing grid.

d) The riser/pigtails from earthing grid shall project 600 mm above grade/concrete level unless shown otherwise.

e) All earthing conductor connections shall be made by electric arc welding or by nuts and bolts using plain washers and spring washers.

f) All arc welding shall be carried out with low hydrogen content electrode.

g) All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. No artificial cooling should be adopted to cool welded joints.

h) The welding required for earthing shall serve the following three purposes (i) sufficient mechanical strength between the jointing materials (ii) sufficient electrical area for the flow of system short circuit current and (iii) sufficient electrical area available after commissioning during the life time of the plant.

i) Before welding, the earth conductors shall be clamped tightly to ensure good surface contact at welding points.

j) Before applying bitumen compound two coats of red oxide primer shall be applied to risers and exposed portion of earth grid, if any. Construction joints shall be given treatment with Barium Chromate before applying red oxide paint and bitumen.

k) Earthing shall be mechanically robust and all joints shall be capable of retaining low resistance even after passages of many fault current.

l) All the connections are to be made carefully and properly. Improper/poor connections are to be remade at the cost of Contractor.

m) Welded areas of risers/pigtail shall be thickly coated with bitumen compound to prevent corrosion.

n) Earthing pits/conductors shall be laid in field to avoid fouling with concrete foundations and in consultation with the Employer at site.

o) Trenches shall be filled up with `Free of Stones' earth after laying earth conductor. After filling up of trenches the earth shall be rammed carefully.

p) The successful Contractor shall submit detailed working drawings of earthing grid for approval by Employer prior to construction of the grounding system.

q) The rate quoted shall be inclusive of cost of all materials, labour required for excavation, backfilling, welding, cutting, bending, placing of GI strips etc. complete as per specification.

r) All tests as per relevant standards shall be conducted to certify the effectiveness and other requirements of the earthing grid.

s) Depth of laying of earth conductor for earth grid, ring and inter-connections shall generally be min. 500 mm from ground level and 300 mm below all foundations.

t) Erection of earth pits shall include making of masonry enclosure and supply of chemical and other materials.

2.2.5.2 Earthing Above Ground

a) The successful Contractor shall lay the above ground earthing conductors inside the buildings and on various structures for connection to various equipment/ drives etc. These earthing conductors may be installed within the cable trays in the form of runway conductors. The connection to equipment shall be tapped from these runway conductors at suitable locations. One runway conductor shall be provided for each side of cable trench/tray.

b) The neutral points of all earthed system of different voltages, all equipment frame works, other non-current carrying metallic structures and equipment such as motor frame enclosures of MCCs, panel boards, cable armour, cable trays, sheaths etc. shall be earthed by a minimum of two separate and distinct connections.

c) Armour of all power and control cables shall be earthed at both ends through gland earth ring provided with the cable glands.

d) All cable trays and supporting structure are to be earthed. All cable tray sections shall be bonded with each other for continuity.

e) All earth leads and riser connections shall be as short as possible.

f) Metal pipes and conduits through which cables run shall be effectively bonded and earthed.

g) Neutral connection shall not be used for equipment earthing.

h) All connections to earth conductors shall be welded/bolted type. Earthing connections to all equipment shall be bolted type.

i) Earthing conductor along their run on steel columns, beams etc. shall be tack welded at intervals of 1000 mm.

j) All joints in earthing conductor shall be welded type. All joints shall be welded with an overlap of 65 mm. Joints shall be thoroughly cleaned before welding. Welding is to be done around joint completely. All joints shall be given two coats of anti-corrosive paint (Red Oxide) to a thickness of 3-5 mils, followed by a coat of bitumen paint. Joints shall be thoroughly cleaned before applying paints.

k) All nuts, bolts washers etc. shall be cadmium plated or zinc passivated. Generally, earthing studs and terminals shall be provided on all equipment. In such cases, where it is not provided the Contractor shall have to drill and tap the equipment for deriving earth terminals.

l) Connections of earthing conductors to the main earthing loops or to equipment shall generally be made by means of cable lugs in case of round conductors, solid or stranded and directly in case of strips. Devices like spring washers and lock washers must be used to ensure that the connections are vibration proof.

m) Laying of earthing conductor shall include fabrication and fixing of clamps, cleats and supply fixing device i.e. nuts, bolts, washers as also civil work such as preparation of floor surface and finishing them to the finished floor level after installation of earthing strips.

2.2.5.3 Earth Pits for Earthing and Lightning Protection Systems

Earth pits shall be based on High Conductivity Technology. In this technology of chemical earthing, a compound of high electrical conductivity shall be filled up in the space around the ground electrode, so that the earth resistance value would decrease appreciably. The high Conductive Compound shall be able to perform in any weather and soil Conditions and shall have following properties;

1. It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.
2. It shall permanently remain embedded and should neither dissolve in and swept away by water.
3. It shall have an ability to absorb large amount of water and retain the same over a long periods of time.
4. It shall decreases earth pit resistance with passage of time.
5. Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.
6. The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.
7. It shall be maintenance free Compound so that there shall be no need of extra water pouring at regular interval as in conventional earthing material, because it should retain the moisture.
8. Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.
9. The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.
10. It shall have low earth resistance, carries high peak current repeatedly.
11. It shall have a Long and reliable life.
12. It shall be easily installed in any soil conditions.

Minimum Electrode size shall be as per the latest amendments of IS:3043. Earth electrodes / plates for body earth, DG & transformer neutral, Instrumentation earthing and Lightning earth pits shall be selected as per the latest amendments / requirements of IS:3043.

All earth electrodes comprising an earth system shall be connected together with a continuous ring of earth tape. After installation, test shall be made to ascertain that the earthing resistance hereinafter specified is obtained. If the required resistance value cannot be obtained, a sufficient number of additional pipes shall be installed, until the resultant resistance not exceeding the specified value can be obtained.

In all cases the pipes shall be driven such that their zones of earthing do not overlap. Each earth electrode shall be connected to its associated earth tape through a linked connection. The link shall be installed as close to the earth electrode as possible. Each earth electrode shall be enclosed together with the link in a reinforced concrete hand-hole with cast iron cover, which shall be set flush with the ground.

2.2.5.4 Earth System

The Contractor shall furnish and install a 75 x 8 mm GI strip as the main grid. The resistance between any point on each earthing system and the earth electrode shall not exceed 0.1 ohm. The overall resistance between the earthing installation and the general mass of earth shall be less than 1 ohm.

The main earthing bars shall be so placed that earthing terminals of major equipment and where required cable sheaths to be earthed, can be readily connected to them. Branch connections from the main earth bars shall be provided to all switchboards, power transformers, capacitors, Control Consoles, distribution boards, etc. The bonds shall be made to the cable glands on which the lead sheath shall be plumed and the armour clamped. All steelwork supporting electrical equipment shall be bounded to the main earthing bars.

The Sizes of GI earth bus and earth wires shall be as follows:

Main earthing grid	75 x 8 mm GI strips
Riser upto ground level	75x8 mm GI Strip
HT & LT switchboards, MCC panels, cable trays, LT motors above 30kW	40 x 6 mm GI strip
High Masts Earthing	40 x 6 mm GI strip
LT Motors > 3.7kW & upto 30kW	25 x 6 mm GI strips
Control desk/Panel, LDB, Weld socket	25 x 6 mm GI strips
Structures	25 x 6 mm GI strips
Lighting panels, Distribution Boards etc.	25 x 6 mm GI strips
LT motors below 3.7kW	8 SWG GI Wire
Junction boxes, field instruments, gland earthing Lighting fixtures, 15A switch sockets	8 SWG GI Wire
Air Conditioner	8 SWG GI Wire

Joints, termination, fixing of the earth bars and their protection from corrosion shall be in accordance with the recommendation given in the aforementioned code of practice subject to the additional requirements specified herein. GI tapes shall be secured at intervals not exceeding 1m by means of single-screw fixing purpose made gunmetal saddle of a pattern approved by the Employer. The tapes shall run in square and symmetrical lines. Links shall be provided in the system adjacent to all junctions to enable tests to be carried out from time to time. All links shall have high tensile steel bolts and the nuts shall be tightened by means of a torsion spanner. All joints in exposed sections shall be protected against moisture and corrosion by the application of two coats of anticorrosive paint and shall be taped with self-adhesive PVC tape.

2.2.5.5 Earthing of Equipment

a) All lighting panels, junction boxes, receptacles, fixtures, conduit etc. shall be grounded in compliance with the provision of I.E. rule.
b) Ground connections of sub-station and meter room shall be made from nearest available 75 x 8 mm ground grid. All connections to ground grid shall be done by arc welding.
c) Lighting panels shall be directly connected to ground system grid by two nos. 25 x 6 mm GI strip at two different locations.
d) A continuous ground conductor of 8 SWG G.I. wire shall be run all along each conduit run and bended at every 600mm by not less than two turns of the same size of wires. This conductor shall be connected to panel ground bus.

All junction boxes, receptacles, lighting fixtures, etc. shall be connected to this 8 SWG ground bus.

e) Earthing of High Mast light towers shall be done by connecting 2 nos. of 40x6 GI strip at two different places.

2.2.5.6 Lightning Protection System

Lightning protection system shall be provided for all the buildings and structures covered under the Scope as per the provisions contained in the latest issues of Indian Electricity Rules and IS 2309. Lightning protection system shall comprise of air terminations, down conductors, test links, earth terminations & earth electrodes.

Material for lightning protection conductor shall be as follows:

- 75 x 8 mm Galvanized steel strip for interconnection between the various earth pits and riser.
- 50 x 6 mm Galvanized steel strip for Horizontal Air termination & Down Conductors
- 20 mm dia 1000 mm long Galvanized steel rod for Vertical air termination
- 40 mm dia 3 m long Galvanized Steel pipe of 6mm thickness with earth pit for Earth termination
- 25 x 6 mm Galvanized steel strip for horizontal conductor on roof along the periphery on parapet wall.

Air termination network shall consist of vertical or horizontal conductors or combination of both. Down conductors should follow the most direct path possible between the air terminal network and the earth termination network. The down conductors should be arranged as evenly as practicable around the outside walls of the structure. Each down conductor shall be provided with a test link for testing. An earth electrode with treated earth pit shall be connected to each down conductor.

2.2.6 Lighting System

General

This specification covers design requirements, supply and installation of lighting system for the project including all buildings and structures.

All equipment and materials shall be suitable for the system voltage. All materials and works shall comply with IS code of practices, Indian Electricity Rules and regulations. The lighting system of particular area whether indoor or outdoor shall be designed in such a way that uniform illumination is achieved. As far as possible, dark spots shall be avoided. This requires careful placing of luminaires, selection of proper mounting heights and provision of supplementary lighting, wherever required. The type of lighting adopted shall provide adequate level of glare-free illumination, without creating undesirable shadows. Design of lighting layout shall be based on the minimum lighting intensities at the working plane and the type of luminaire specified as under:

Location	Average lux level	Type of Luminaire
Open Area and Jetty Area	30	350 W LED Flood Light, weather proof, Heavy duty High Mast light in die cast Aluminium alloy housing
Electrical Substation, Transformer, DG Room, Worker's Amenity Building, Sewage Treatment Plant, Weigh Bridge Building & Security Office	200	General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink
Terminal Admin. Building	300	34Watt LED Panel with ultra modern recess mounting luminaire suitable for armstrong/grid/POP ceiling complete with separate electronic driver & high brightness SMD LEDs
Electrical Substation, Terminal Admin Building, Worker's Amenity Building, Security Office, Weigh Bridge, STP, all exit / entry points etc.	10	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup
Road light	20	70 Watt LED with single / double arm 9 meter hexagonal GI pole with FRP J.B and required accessories.

Luminaires

a All luminaires shall be industrial/decorative type as specified. Where the specific type of luminaire is not indicated, the Contractor shall select suitable type of LED luminaires to meet the requirement. Special luminaires may be provided when required by the seeing task or architectural treatment. The number of different type of luminaires and their wattages shall be minimum consistent with the lighting requirements.

b While using discharge lamps, stroboscopic effect shall be minimized by various methods, which should be considered while planning lighting installation. All fluorescent fittings

shall be of rapid start type and shall be so arranged that the power factor will be 90% or higher.

c All luminaries along with its terminal boxes shall have IP56 degree of enclosure protection for internal areas and IP65 degree of enclosure protection for external areas and battery room.

Emergency Lighting

For safety and protection of personnel and for shutdown of the equipment, battery operated lighting units shall be installed as a part of fixed wiring system. Battery operated lighting unit shall consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type with fully automatic 5V DC Li-ion charger, transfer switch to automatically transfer from main supply to the battery and vice versa. The charger shall be capable of recharging fully in 12 hours. The unit shall operate on 1 Ph 240 V 50 Hz. Emergency lighting shall be designed to ensure minimum 10 lux in all the areas to ensure safe evacuation of persons in case of failure of both mains and DG supply.

Lighting Installation

All installation shall be of rigid steel conduit executed to IS: 1653. Minimum diameter of conduit used shall not be less than 19 mm. Conduits shall be concealed wherever practicable. The number and size of wire in any conduit shall not exceed that stated in IS regulations. Not more than three (3) lighting circuits or two (2) socket circuits shall be bunched in the same conduit. The wiring from the lighting panel to the outdoor lighting fixtures shall be done by PVC armoured, 650/1100V grade cable. For control room lighting stranded Cu conductor shall be used. The minimum size of conductor shall be 2.5 sq. mm. copper.

2.2.7 Switchgear

Design of the Switchgear shall be in accordance with the requirements of these specifications and the best current engineering practice, together with the following general requirements:

a Switchgear shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.

b All panels, boards, etc. shall be suitably labeled with labels of design approved by the Engineer.

c Equipment shall be installed indoor/outdoor in a hot, dry climate. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

d Maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating, of the equipment shall be made taking 45OC as an ambient temperature.

e The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:

- Mechanical damage to any part of the switchgear.
- separation of contacts
- insulation damage of "Current Carrying Part"

f Transformer primary circuit breakers and the secondary circuit breakers should be arranged for inter-tripping as follows:

- Tripping of transformer primary circuit breaker, either manually or automatically on fault shall intertrip the transformer secondary circuit breaker.
- Tripping of the transformer secondary circuit breaker on fault shall intertrip the transformer primary circuit breaker.
- Manual tripping of the transformer secondary circuit breaker will not intertrip the transformer primary circuit breaker.

g All controls shall be suitable for 240V AC / 110V DC.

h At least 20% spare with at least one number of each type of feeder shall be provided as spare on either side of the BUS for LT Panels. The spare feeders selected shall be with highest rating in the event of reoccurrence in same type.

2.2.8 Cables

Cable Selection Criteria

a) HT (11KV) Cables Fault level withstand KA:

- 1 sec. for Main incoming cables
- 0.5 sec. for outgoing feeder cables

b) LV Cables Fault level withstand kA:

- 1 sec. for Main incoming cables from Transformer
- For outgoing feeder cables, withstand time based on fault clearance time of ACB/MCCB

c) Permissible Voltage drop in Cables:

- Transformer to Switchgear Busbars: - 1%
- Switchgear, PCC to Motor: - 3%
- Switchgear, PCC, ACDB, MLDB to Lighting DB (LDB): - 2%
- LDB to farthest lighting fixture In the circuit :- 2.5%
- Starting Voltage drop of Motor: 15%
- Running Voltage drop of Motor: 3%

d) Other factors to be considered:-

- Short circuit capacity to be considered while selecting HT cables
- Factor for Ambient temp. $45^{O}C$
- Grouping Factor for Cables laid touching in single/ multitier racks.
- Grouping Factor for Cables laid Buried
- 10% reserve capacity in cable over the load current requirement.

The cable shall be laid on cable trays / in cable trenches in sub-station rooms. In some cases cables may also be laid buried.

Cable Laying and Terminations

The cables shall be laid using the following methods.

- Laying direct in ground
- Laying in pipes
- Laying in Concrete trench
- Laying in cable tray running along cable corridor

While laying the new cables or rerouting the existing cables, successful Contractor shall take all safety measures and manual excavation operations are preferred.

a) Laying Direct in the Ground

Laying and installation of directly buried cables in ground shall conform to the requirements of IS:1255. This shall consist of excavating suitably dimensioned trench in ground, and directly laying cable on a bedding of riddled soil free from potentially corrosive elements, or sand at the bottom of the trench encasing cable with half round cut pipes, covering cable with additional riddled soil or sand, and filling up the trench. Depth of laying and formation of cables shall be as per IS:1255. A minimum separation of 300 mm shall be maintained between power and communication cables.

b) Drawing into Pipes

This system shall consist of required number and size of double wall corrugated pipes conforming to applicable requirements of IS or BS with simplex joints. Conduits shall be completely enclosed in concrete. Clearance between conduits comprising a duct shall be 50 mm on the sides, bottom and top. Conduit joints in concrete encasement may be placed side by side horizontally but be staggered at least 15 cm vertically. Duct lines shall be laid to a minimum gradient of 1:300. Conduit shall be thoroughly cleaned before using or laying. Particular care shall be taken to keep the conduits clean of concrete, dirt and any substance during the course of construction.

The cable route shall be generally be indicated by painting the concrete slabs. Where ever applicable cable route markers circular in shape galvanized and route direction indicated by an arrow shall be provided. This system of cable laying shall be adopted while cable is to be laid across roads, railway lines, water ways, and in such situations where subsequent excavation of a trench is both expensive and inconvenient.

c) Laying in Concrete Trench

- This system of cable laying shall be adopted inside electrical substation.
- Ladder type FRP cable trays shall be used for cables in the RCC trench.

Successful Contractor shall prepare actual drawings as per the requirement and obtain approval from the Employer before executing the same.

2.2.9 Cable Trays and Fittings

The size of cable tray shall be to suit the cable requirement of the particular section. However, successful Contractor shall provide the number of cables and tray size required.

A) Design Requirements and Construction

Cable trays and accessories shall be Fibre Reinforced Plastics (FRP) as per NEMAFG 1 1984-1993 with minimum thickness of 3mm upto 200mm width and 4mm above that. Horizontal rung spacing shall be 250mm.

Cable trays shall be in piece length of 2.5 meters. Tray ends shall be connected to either other straight tray or horizontal elbow, vertical elbows, Tee, cross, reducer etc. by using coupler plates. The bending radius on minor side of bends shall be 600 mm. Bends of

lesser/bigger radius shall be made if warranted. Cable trays shall be supplied complete with side coupler plate and necessary nuts and bolts. Required number of reducers, bends, crosses, tees shall also form part of the supply.

To facilitate assembly, all accessories at ends shall have 100 mm straight portion. The width and length of trays and accessories shall be within a tolerance of ±3 mm. The Contractor shall have to secure racks and supports by suitable methods on available building/structural steel and the required accessories shall form part of the supply. In some areas, the Contractor may have to secure the supports on wall, ceiling or floor by suitable anchoring.

Fifty (50) percent spare space shall be provided in the cable trays, racks and risers.

All welded joints shall be smooth enough to provide a good appearance and shall not cause any injury to working personnel or any damage to the cable laid directly on it. All welding work shall be carried out by electric arc welding method only. Necessary welding sets, all consumables etc. to be arranged for the Contractor.

Successful Contractor shall prepare the actual drawings as per the requirement and obtain approval from the Employer before executing the same.

B) Cable Clamps

Trefoil clamps for single core cables shall be pressure die cast aluminium (hot galvanized) or fibre glass or nylon "claw" type and shall include necessary fixing accessories like GI nuts, bolts, washers etc. Trefoil clamps shall have adequate mechanical withstand capability in case of a fault and shall be tested and proven type. For clamping the multicore cables self-locking, de-interlocking type nylon clamps shall be used.

C) Cable Glands and Lugs

Double compression type tinned, of coating thickness 20 microns, brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof sealing. Rubber components used in cable glands shall be neoprene or synthetic rubber and of tested quality.

Cable lugs shall be tinned copper of approved design/make, solderless crimping type conforming to IS. Cable lugs for control cables and special cables shall be suitable for copper cable. Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided on the equipment. Crimping tool used shall be of approved design and make.

3 GENERAL REQUIREMENTS

3.1 Site Acceptance and Mobilization/Demobilization

3.1.1 Acceptance of Site

In accordance with these specifications, the Contractor shall have examined the site and familiarized himself with all existing conditions. He shall accept the site in its existing condition at the time of award of contract.

3.1.2 Mobilization

Upon award of the Contract and within a reasonable time but not exceeding 2 months the Contractor shall mobilize all such labour, equipment and materials that are necessary to complete the project in due time.

3.1.3 Demobilization

Upon due performance of the Contract and before the Taking Over Certificate is issued to the Contractor, he (the Contractor) shall demobilize all such labour, equipment and materials that are necessary to clear the site within one (1) month to the Employer's approval.

3.1.4 Access

The Contractor shall provide and maintain adequate access to the project site and all areas related to the works at his expense. If existing roads are to be used for access to the site, the Contractor shall maintain such roads for the duration of their use.

3.1.5 Permits and Licenses

Except as expressly stated in the Employer's Responsibilities, the Contractor shall obtain all permits and licenses necessary for the execution and completion of the Works. The Contractor shall pay all associated fees including royalty. He shall also give the Employer a copy of all relevant correspondence and other documents relating to the Contractor's permits and licenses.

3.2 Temporary Works

The Contractor shall design, install and maintain all temporary facilities required for the construction of facilities under this contract Package, which he requires on or at the site throughout the execution of the work, and remove the same on completion of the works. He shall provide all such buoying, fencing, watching, lighting, connections to public utilities etc. as he needs or as required by authorities and shall install and use his temporary facilities in accordance with all statutory regulations and the requirement of the relevant authorities.

The Contractor shall submit his plan for temporary works to the Employer, for approval, within 30 days of award of contract.

Temporary construction shall be adequate for intended uses and for all loads imposed without excessive settlement, deflection or deformation. All parts and members shall be properly strengthened to prevent displacement or failure.

Before or upon completion of work, unless otherwise required or directed, preparatory structures, installations and utility services shall be disconnected and removed from the site.

3.2.1 Utilities

Temporary utilities used for construction shall have to be adequate for the intended uses and not to be overloaded or otherwise used or arranged in any manner endangering

persons, premises or works. Connections shall be properly made, lines and wiring securely anchored in place and protected against accidents. There is no utility existing in the terminal area.

Shifting of utilities, if any, within the project site shall be the responsibility of the contractor.

3.2.1.1 Water

The Contractor shall provide his own arrangements for sourcing and for distribution adequate supply water for the Project including:

- Drinking water: Providing and maintaining canisters, coolers or connected drinking fountains of sufficient number to reasonably serve the Project.
- Construction water: Providing and maintaining temporary water service and distribution of adequate capacity for construction

3.2.1.2 Electricity

The Contractor shall make his own arrangement for power supply.

If found necessary, the Contractor shall provide and maintain generators including a stand-by generator of adequate capacity to meet his additional Project requirements.

The Contractor shall make his own arrangements as outlined hereunder:

- Distribution of adequate capacity for power, lighting and other construction needs.
- As necessary to properly and safely perform work at enclosed spaces or under hazardous conditions. Likewise, providing lights for night work/ protection as necessary.

Temporary electrical systems shall comply with the local codes and regulations.

3.2.2 Waste and Rubbish

The Contractor shall provide regular daily clean-up and removal of trash, waste, scraps, construction debris, etc. from site and temporary work yard and shall arrange for disposal of waste and rubbish to disposal areas approved by the Employer.

3.2.3 First Aid and Fire Protection

3.2.3.1 Emergencies

The Contractor shall maintain the lists of nearest available police, hospital or medical services at the Contractor's Site Office and the same are to be displayed at a number of locations & work places.

3.2.3.2 Fire Protection

The Contractor shall establish and submit the following measures to the Employer.

- Establish appropriate emergency escape routes and procedures;
- Maintain fire extinguishers, connected hoses and other facilities necessary for reasonable fire-fighting action at the site and temporary work yard;
- Provide and maintain a first aid kit containing bandages, medicines and sterilized materials for first aid treatment of minor injuries at the Contractor's Site Office.

3.2.4 Construction Safeguards

3.2.4.1 Excavations

Trenches intersecting roads shall have to be provided with crossings suitable to carry the type of traffic involved. Vehicular curbs and pedestrian railings shall be provided as necessary. Open pits and in openings in floors and other accessible surfaces shall be protected by barricades or railings.

3.2.4.2 Access

Access to structures such as scaffolds, ladders, ramps, hoists etc. shall be provided, maintained and operated as necessary.

3.2.4.3 Storage Areas

Storage and shop areas shall be provided, arranged and maintained at approved locations as necessary to properly store, handle and fabricate the various materials and equipment required.

3.2.5 Protection of the Public

The Contractor shall provide barricades and enclosures as necessary for public protection.

3.2.6 Contractor's Laboratory & Equipment

The Contractor shall provide site laboratory in order to carry out the specified tests. This laboratory shall be completely staffed and properly equipped to the approval of the Employer to carry out the tests as specified.

The Contractor's site laboratory shall be available for the use of or inspection by the Employer as required by him. The Employer may require his representative to be present at any test and at any time during the working hours of the laboratory.

The Contractor shall furnish and maintain the laboratory, apparatus and supplies necessary to permit execution of the tests required by the Specifications. The Contractor shall submit to the Employer for his approval, within 28 days after award of work, a complete list of the equipment, apparatus and supplies he proposes to furnish the laboratory. The list shall include the manufacturer's name and descriptive literature.

List of instrument, tools & tackles required for Material testing laboratory /QA facility at project site to be submitted by the bidder for Employer approval.

3.3 Environmental Protection

The Contractor shall comply with all the conditions stipulated by the relevant statutory and regulatory organisation of Govt. of Bihar / Govt. of India.

3.3.1 Fires

Fires and burning of rubbish on the Site are not permitted except when authorized by Employer.

Where fires or burning is permitted, the Contractor shall prevent the structures which are to be preserved from staining and smoke damage. The Contractor shall restore, clean and make good stained or damaged work to new condition.

3.3.2 Disposal of Waste and Cleanliness

The Contractor shall not bury rubbish and solid waste materials on the Site and he shall not dispose of waste or volatile materials, such as mineral spirits, oil or paint thinner into the waterways, storm water drainage or sanitary sewers.

The Contractor shall keep all pavements and areas leading to and from the site, clean and free of mud, dirt, and debris at all times for movement of vehicles and pedestrians.

3.3.3 Drainage

The Contractor shall provide temporary drainage and pumping facilities as necessary to keep the adjoining areas of work site free from water logging and flooding.

3.3.4 Pollution Control

The Contractor shall cover or wet down dry materials and rubbish to prevent blowing dust and debris, and provide dust control for temporary roads and yards.

The Contractor shall take all measures necessary to ensure that no pollution of the waterways or any land areas occurs as a result of his activities. He shall undertake at his own expense all measures necessary to clean up or otherwise rectify any pollution arising from his activities under this Contract to the approval of the Employer.

3.3.5 Environment

The Contractor shall deploy most suitable construction equipment to minimise the suspension of fine sediments at the work site.

3.4 Submission of Documents during Project Execution

3.4.1 Programme of Works

The Contractor shall prepare and submit (both hard copy and soft copy) to the Employer within 30 days of receipt of Letter of Award the following:

- Detailed CPM Schedule showing the various activities of the Work using MS Project
- List of designs/drawings/documents along with their schedule of submission.
- List of Vendors/Suppliers of Bought-out items

The above shall be updated every month and submitted to the Employer.

3.4.2 Work Schedules, Survey Data & Drawings

The Contractor shall prepare and submit construction schedules, survey data, and field drawings to illustrate the appropriate portion of work. The work items shall be described and related to responsibility, fabrication, layout, and setting or erection details as specified in appropriate Sections.

The Contractor shall keep allowance in program of works for any stoppages during monsoon period, and he has to take all necessary measures to protect his equipment and the partly completed structures. The Contractor is expected to build such stoppages of work during monsoon in his overall schedule for completion. The Employer will not entertain any claims from the Contractor on this account.

Drawings shall be submitted in five sets / as per requirement, of paper prints, maximum size 1189mm x 841mm and on CD (in AutoCAD format).

3.4.3 Maintenance Plan

3.4.3.1 General

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life.

3.4.3.2 Maintenance Document

The Contractor shall provide six copies of the maintenance plan and manuals to the Employer to retain by the Employer upon the request of the Employer or following receipt of attention to the Employer's comments.

3.4.4 Weekly and Monthly Progress Reports

The Contractor shall maintain a daily log describing the important events pertaining to the Works, (the working hours, the number of labourers employed, effective operation time of equipment, overtime hours), progress made in the Works. This daily log shall be submitted to the Employer by 1:00 PM of the following day. Compilation of these logs and their summary shall be submitted to the Employer as Weekly Progress Report in three (3) copies by middle of the next week.

The monthly progress reports shall include progress photographs taken at a fixed point and angle. The photographs shall be sufficient in numbers and locations to record the exact progress of works. The colour photographs shall be in size 200 mm x 250 mm and the CD containing the digital version of the same shall be provided.

The Contractor shall furnish the Employer with five (5) copies of the monthly progress reports within seven (7) days after the end of every month.

3.4.5 Design & Drawing Submissions

3.4.5.1 Design Submissions – General

The scope drawings listed in this Volume is issued for information and guidance to the extent mentioned in the Tender document. Contractor shall make all arrangement and design drawings and submit the same for approval to the Employer/Engineer. Detailed Engineering shall be done by the Contractor. The contractor shall not be entitled to any extension of time for completing construction/commissioning or any other relief on account of delay caused due to providing any clarifications or in resubmitting any designs and drawings.

The contractor shall not change any design and drawings reviewed by Employer/Engineer, without submitting such revised designs and drawings for the review of Employer.

The Contractor shall submit for the approval of Employer, progressively from the date of receipt of the Letter of Award, Five (5) copies of the following:

- Layout of Terminal
- General arrangement of all structures
- Cross sections and other details showing important particulars such as overall dimensions, clearances, etc.
- Specification/catalogues of all standard bought-out items.
- All drawings other than shop fabrication/manufacturing drawings. These will include, but not be limited to assembly, sub-assembly, key components, etc. However, one week

prior to fabrication, fabrication and part drawings shall be made available to the Employer.

- Power Requirement (installed and peak demand loads)
- Wiring drawings and equipment inter-connection diagrams of local control panels & Single Line Diagram of facility power distribution.
- All design calculations pertaining to all structures.

A further digital copy (in AutoCAD format) of the submission shall be given on compact disc. This digital copy shall include the full submission with scanned copies of any documents prepared by hand.

The list of submission will however be discussed with the Contractor after the award.

3.4.5.2 Submission of Calculations

All calculations submitted for the Employer's approval shall comply with the following:

a. Each calculation page shall be uniquely numbered.

b. Each section of calculations shall have a cover sheet, listing the subject of the calculations, document number and date of submission, name and qualifications of the Designer(s), the name and qualifications of the Design Verification engineer(s), and the relevant Standards, books and drawings which are the basis of the calculations.

c. Each section of calculations shall have a Table of Contents, including page numbers.

d. Calculations shall be accompanied by all necessary sketches or extracts from drawings.

e. Calculations shall include introductions explaining the purpose of the calculations and the methods and design philosophies adopted. This shall clearly state the Standards on which the calculations are based.

f. Equations and values from International Standards and Codes of Practice are to be clearly referenced which are used in the design shall be attached to the submission.

g. Where values used in the calculations are brought forward from previous calculation pages, the page reference shall be included.

h. At the end of each section there shall be a summary, listing the conclusions of the calculations, and referring to construction drawings.

i. If calculations are revised due to design changes or corrections or comments of the Employer, the calculations sheets shall be clearly marked with a revision letter.

j. All calculations shall be signed / initialed by the designer and design verification engineer.

k. The design calculations shall be written in English. In case any software is utilized to perform the calculations a sample set of manual calculations with references of various formulae used shall also be submitted for proper verification.

3.4.5.3 Submission of Drawings

All drawings submitted for the EMPLOYER'S approval shall comply with the following:

1. All drawings shall be in metric millimetre dimensions, and be finally prepared in ink with legible lettering on either A0 1189mm x 841mm using AutoCAD format compatible with AutoCAD 2014 or lower version. The submitted prints shall be clearly legible throughout and there shall be no ambiguity.

2. All drawings shall be submitted in digital format on compact disc, as well as three paper prints.
3. Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.
4. Drawings from various sub-contracting services, specialist suppliers etc. shall also be presented in a similar manner (identical title blocks/format etc.) to provide a matched set of drawings.
5. All drawings shall clearly show the status and revision of the drawings. Revised drawings shall clearly indicate the nature and details of the revision work and also revision cloud & revision mark shall be marked wherever revised.
6. All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.

Each drawing shall show the scale(s) of the components illustrated by the drawing related to the original drawing size, A0, A1, A3 etc.

3.4.5.4 Inspection of Drawings at Site

The Employer shall have the right at all reasonable times to inspect all drawings at the premises of the Contractor or call for any drawing to be given to Employer's office.

3.4.5.5 Manuals and Technical Data

A) Manuals

The Contractor shall supply Five (5) hard copies along with One (1) soft copy (in editable format) of Erection & Installation Manuals, Operation Manuals, Spare Parts Manuals and Inspection and Maintenance Manuals prior to the starting of erection. Recommendations of the manufacturer in respect of preventive maintenance, trouble shooting, and breakdown maintenance and over haul shall be brought out in the inspection and maintenance manuals. Soft copies of all drawings shall be supplied.

Operating instruction manuals shall be provided at the time of shipment with adequate information pertaining to the following:

- Programming procedures;
- System specifications;
- Electrical power requirements;
- Expansion of internal fault diagnostics;
- Troubleshooting procedures;
- Powering up procedures;
- Shut down procedures

B) Technical Data

i) On completion of the works and before handing over possession to Employer, the Contractor shall supply Five (5) hard copies together with One (1) soft copy of the following:

- Shop drawings of all wearing parts and also major assemblies and minor assemblies which require unit replacement;

- All “As Built” Drawings of equipment, civil / structural, electrical items etc.

ii) Complete technical data and dimensional drawings of all bought out product/ items in the system, shall be furnished - Six (6) hard copies together with One (1) soft copy of the following:

- List of recommended spare parts.
- Parts catalogues in the case of all equipment /assemblies illustrated with part numbers in drawings both for electrical and mechanical items.

3.4.5.6 Tools and Maintenance Equipment

A list of complete set of tools/tackles and instruments required to be provided for satisfactory maintenance of the Works shall be furnished.

3.4.5.7 Maintenance Plan

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer as per the requirement of this tender document. This plan shall be prepared to ensure that the design life periods stated in Tender are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life. Contractor shall also furnish list of estimated manpower required to perform monthly plan.

3.4.5.8 As Built Drawings, Design and Final Construction Report

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to two (2) sets of as-built drawings, final design in the supporting of as-built drawings and a final construction report as draft. And within thirty (30) calendar days after receipt of comments from the Employer, the Contractor shall submit five (5) sets of the Final Construction Report and five (5) sets of Final As-built drawings & Design documents. As-built drawings of the works consists of two (2) sets of original size copies (white print) and six (6) sets of bound copies reduced to A3 size. All documents and drawings shall be also delivered on CDs (drawings in Auto-CAD format, documents in other required formats and soft copy of the file used in software on which design was carried out).

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to five copies of manuals for installation, commissioning, operation and maintenance and the drawings/ documents etc., covering all aspects of the Works for the review of the Employer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life. In the event the Contractor makes any changes effecting such submission the Contractor shall submit afresh such document duly revising to that extent.

3.5 Quality Control and Assurance

3.5.1 General

The Contractor will be required to adopt a system of self-certification in accordance with his general quality plan and the appropriate detailed quality procedures. The quality system shall comply with Standards of ISO 9001.

The Contractor shall monitor his performance of executing his Works against two levels of certification:

- The completion of individual work items
- The completion of activities listed in the Programme.

In addition to the certification of the completion of work items and activities, the Contractor shall be required to issue the Quality Assurance (QA) certificates concerning the Quality Plan, Quality Procedures and Construction Documents.

The Employer may monitor the Contractor's work against the Contractor's Quality Plan and Quality procedures. The Employer may do this by spot checks, and/or by continuous monitoring of the work. The Employer may also do this by carrying out compliance audits periodically against the Contractors Quality Procedures. The frequency and intensity of such checks will depend on the proven reliability of the Contractor as work progresses. Each non-compliance with the Quality Plan shall be notified promptly to the Employer by the Contractor, together with proposals for remedy of the non-compliance. The absence of monitoring of or commenting on quality aspects as above by the Employer shall not absolve the Contractor from any of its contractual obligations and/or shall not entitle the Contractor for any claim.

3.5.2 Improper Certification of Unsatisfactory Work

If the Contractor or its personnel repeatedly confirms/declares a work as being satisfactory when such work is not satisfactory, the Employer may reject such work any time during the currency of the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of improper certification and/or Contractor's failure to rectify, the Employer may proceed as per the Contract including terminating the Contract.

3.5.3 Quality Plan and Quality Procedures

The Contractor will be required to submit his complete General Quality Plan to the Employer within four weeks of the Commencement Date. A designer's quality plan will be accepted as an interim measure to permit design work to be started in advance of the preparation of the General Quality Plan.

Detailed Quality Procedures for each element or item of work must be submitted to the Employer for review at least four weeks before that work is due to commence. Detailed Quality Procedures are required for all items manufactured prior to delivery to site.

3.5.4 Submission and Certification of Construction Documents

The Contractor shall submit a Design Certificate (in duplicate) and Design Check Certificate whenever he is submitting Construction Documents to the Employer for review. Construction Documents submitted without the relevant Design Certificate will not be reviewed.

The Contractor is to ensure that all Construction Documents submissions are in a form that enables the Employer to review the Construction Documents as required by the Contract without delaying completion of the Works.

3.5.5 Certificates for Work Item Completion

Readily identifiable Work Items must be certified as checked and found satisfactory by

a) Contractor's surveyor responsible for checking and

b) Contractor's supervisor responsible for checking temporary works, material cleanliness, dimensions (not checked in (a) above), workmanship and all other matters to enable him to certify that the item of work complies in every respect to the contract.

The Work Item Completion Certificate shall be checked and approved by the Contractor's Quality Manager.

Each Work Item Completion Certificate must be identified by a unique and appropriate reference number.

If the Employer is not satisfied that the works have been carried out satisfactorily as certified, the Employer shall raise a non-conformance report to which the Contractor shall respond stating his proposals for rectifying the non-conforming item and what action will be taken to prevent recurrence. The Employer may reject such work any time during the currency of the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of recurrence/failure of the Contractor to rectify, the Employer may adjust the Contract price by deducting the value of such work.

Any consequences in respect of any revisions arising out of Work Item Completion Certificates being returned with comments shall not be treated as a compensation event.

3.5.6 Certificates for Activity Completion

When a section of work has been completed satisfactorily, the Contractor shall certify that the activity has been completed in accordance with the Contract.

The Activity Completion Certificate shall be checked by the Contractor's Quality Manager and confirmed by the Contractor. The Designer's Representative shall also certify that the activity has been completed in conformance with the relevant Construction Documents and the EMPLOYER'S Requirements.

The Activity Completion Certificate shall list the reference numbers and dates of Work Item Completion certificates that have been relied upon by the signatories to the Activity Completion Certificate.

Each Activity Completion Certificate shall have attached to it, copies of any materials test certificates which were received after signing the relevant Work Item Completion Certificates and which have not been submitted to the Employer under separate cover during the period between the signing of the Work Item Completion Certificate and the preparation of the Activity Completion Certificate.

3.6 Field Surveys and Investigations

3.6.1 General

The Contractor shall carryout the engineering design and prepare drawings for the various components under this specification, based on the data on field surveys and investigations, including that of Temporary Works.

The Contractor shall carry out all necessary investigations to supplement and complete his design data:

- Topographic survey to supplement the survey carried out by the Employer.
- Soil investigation work to supplement the investigations carried out by the Employer to verify that his design assumptions are in accordance with the ground conditions.

The Contractor shall, at his own expense, carry out all the necessary surveys, measurements and setting out of the works and shall for this purpose engage well qualified, experienced and competent land surveyors.

3.6.2 Setting Out

The Contractor shall establish working bench marks related to the Reference Bench Mark in the area soon after taking possession of the site. The Employer shall provide the Contractor with one Permanent Bench Mark and its datum. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Employer. These marks shall be maintained until the works reach finished formation level and are accepted by the Employer.

The Contractor shall be solely responsible for safe-guarding all survey monuments, bench marks etc. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issue under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Employer of any apparent errors or discrepancies in such dimensions and levels.

3.6.3 Topographic Surveys

The Contractor may conduct a precision triangulation survey to establish primary and secondary survey stations and tie these with respect to Spheroid WGS 84 UTM grid for setting out the Works.

Survey stations and other control devices required by the Contractor for his execution of the work shall be established by the Contractor at his own expense, and shall be removed upon completion of the works.

3.6.4 Geotechnical Investigations

The Contractor shall carry out additional geotechnical investigations in the Works area.

3.6.5 Post Construction Survey

The completion of the works will be examined by the Contractor in the presence of the Employer. During these examinations, the Contractor shall perform the survey, which shall be used to prepare a final drawing showing all dimensions, elevations and cross sections of the "As Built" conditions of the structures. The Contractor shall be required to remove excess materials or place additional materials, as directed by the Employer, in order to comply with the Contract Documents. Contractor shall submit the final location of all structures with reference to the Master Grid, which shall show the actual position of each structure and deviation from the theoretical position.

3.7 Employer's Responsibilities

3.7.1 Datum Points and Levels

The Employer will give the details of a reference Bench Mark in the vicinity of the Project Site and the Contractor shall establish working benchmarks linked to this and reduce to Mean Sea Level (MSL). The Contractor prior to the start of works shall confirm the location and details of datum points and levels. The Contractor shall convert all the levels accordingly with respect to MSL.

3.7.2 Contractor Working Area

The Employer shall provide land area maximum of 5 acres at one / two places within the Project Site for the Contractor's working area like site establishment, installation of batching plant, casting yard, etc. No space for the labour camp shall be provided.

4 SPECIFICATIONS – CIVIL

4.1 Materials

4.1.1 General

The Contractor shall be responsible for furnishing all materials required for execution of the Works. The Contractor shall submit the source and method of execution for the Employer's review before any execution. All materials used in the construction of permanent works required under this Contract shall be of 1st class quality as specified herein and comply with the latest IS Codes or equivalent. The material shall be tested before bringing it to the site.

This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

Whenever any reference to IS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the Tender.

Apart from the IS Codes mentioned in particular in various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/or inspection procedures shall be applicable. Reference to some of the codes in various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

In case of any variation/contradiction between the provision of IS Codes and this specification, the provision given in this specification shall be followed, unless the Employer agrees/consents to follow IS codes or other proposal of the Contractor as provided in the Contract.

All materials shall be of standard quality and shall be procured from renowned sources/manufacturers approved by the Employer. It shall be the responsibility of the Contractor, to get all materials/manufacturers approved by the Employer prior to procurement and placement of order.

Wherever brand is not mentioned, Contractor can choose a brand complying with the tender specifications however mentioning the brand considered in the Bid submission for the approval of the Employer if required.

Whenever called for by the Employer, all tests of the materials as specified by the relevant IS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Employer for his approval. If so desired by the Employer, tests shall be conducted in the presence of the Employer or his authorised nominee.

Quality and acceptability of materials not covered under this specification shall be governed by the relevant IS Codes. In case IS code is not available for the particular material, other codes e.g. B.S. or DIN or API/ASTM etc. shall be considered. The decision of Employer in this regard shall be final and binding on the Contractor.

Whenever asked for, the Contractor shall submit representative samples of materials to the Employer for his inspection and approval. Approval of any samples does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant IS Codes.

The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Employer from asking fresh test results from an approved laboratory of the

actual material supplied from an approved manufacturer/source at any stage of execution of work.

All costs relating to or arising out of the tests and submission of test reports and or samples to the Employer for his approval till the date of issuance of Performance Certificate shall be borne by the Contractor.

Materials for approval shall be separately stored and marked, as directed by the Employer and shall not be used in the Works till these are approved. All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

4.1.2 Water

Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances, which may be deleterious to concrete, masonry or steel. The ph value of water sample shall be not less than 6. Potable water shall be considered satisfactory.

Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfil all the guidelines and requirements given in IS:456.

The Employer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall not have average 28 days compressive strength lower than 90% of the strength of concrete prepared with distilled water.

The Employer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Employer may refuse to permit its use. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

Water shall be stored in tin barrels, steel tanks or water tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirements, at any stage of construction.

Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydro-testing and checking the leakage of liquid retaining structures also.

4.1.3 Aggregate

4.1.3.1 General

Coarse and fine aggregates for civil and structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be chemically inert, hard, strong, dense durable, clean and free from veins, adherent coatings, injurious amount of alkalies, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.

Source and type of aggregates shall be got approved by the Employer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, the Employer subject to the Contract may accept the proposal

to change. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer. Aggregates, which may chemically act with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 – Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the Contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

Coarse and fine aggregates shall be batched separately. All-in-aggregates shall be used only where specifically permitted by the Employer.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/all batches of coarse and fine aggregates, and submitted to the Employer, whenever asked for, to ensure conformity with those submitted along with the mix design.

Whenever required by the Employer, the aggregates (coarse/fine) shall be washed and/or sieved by the Contractor before use in the works to obtain clean and graded aggregate at no extra cost to the Employer.

Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

4.1.3.2 Coarse Aggregates

Coarse aggregates are the aggregates, which are retained on 4.75 mm IS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

These may be obtained from crushed or uncrushed gravel or stone as per Clause 4.1.3.1 and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS:383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the Contractor shall submit to the Employer at least three sets of mix design and test results, each with different grading of coarse aggregates, proposed to be used. The Employer may allow “All-in-aggregates” to be used provided they satisfy the requirements of IS:383.

4.1.3.3 Fine Aggregates

Fine aggregates are the aggregates which pass through 4.75 mm IS sieve but not more than ten percent (10%) pass through 150 micron IS sieve. These shall comply with the requirements of grading zones I, II, III and IV of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shores, creeks or river banks affected by tides, dredged sand shall not be used for filling or concrete works.

4.1.3.4 Sampling and Testing

Storage of all types of aggregates at site of work shall be at Contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Employer for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

4.1.4 Sand

4.1.4.1 Sand for Masonry Mortars

The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.
The crusher sand / manufactured sand with grading limits satisfying requirements of IS 383 shall be considered.

The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the concrete.

Unless found satisfactory as a result of further tests as may be specified by the Employer, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

4.1.4.2 Grading of Sand

The particle size grading of sand shall be within the limits as specified below:
Grading of Sand

IS Sieve Designation	Percentage	Method
IS:460 (Part I)	Passing by Mass	
4.75 mm	100	IS:2386 (Part I)
2.36 mm	90 – 100	
1.18 mm	70 – 100	
600 micron	40 – 100	
300 micron	5 to 70	
150 micron	0 to 15	

4.1.4.3 Sampling and Testing

The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of IS:2386. Any test which the Employer may require in connection with this shall be carried out in accordance with the relevant parts of IS:2386.

If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

4.1.4.4 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Employer. Sand obtained from sea shores, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS-383 shall be allowed for filling.

4.1.5 Cement

For plain and reinforced concrete works cement shall be of any of the following types:

- 43 Grade OPC Ordinary Portland cement conforming to IS 269
- Portland slag cement conforming to IS 455
- Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)
- Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)

For marine structures , the above mention types of cement shall also confirm to IS 4651 Part 4.

Chlorides in the concrete

Whenever there is chlorides in concrete there is an increased risk of corrosion of emb edded metal. The higher the chloride content or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, that is, cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below.

Limits of Chloride Content of Concrete

Sl. No	Type or Use of Concrete	Maximum Total Acid soluble Chloride Content Expressed as kg/m3 of Concrete
1	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
2	Reinforced concrete or plain concrete containing embedded metal	0.6

3	Concrete not containing embedded metal or any material requiring protection form chloride	3.0

The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Whenever possible the total chloride content of the concrete should be determined as per the approval of the Engineer-in-Charge.

Sulphates in concrete:

Sulphates are present in most cements and in some aggregates; excessive amounts of water –soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO3, should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix as per the approval of the Engineer-in-Charge.

The 4 percent limit does not applied to concrete made with super sulphated cment complying with IS 6909 or as approved by the Engineer-in-Charge.

4.1.5.1 Storage at Site

The storage of cement at the site of work shall be at Contractor's expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent determination due to moisture.

All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer. The Contractor shall maintain a register, on day to day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer for verification.

4.1.5.2 Tests after Delivery

Each consignment of cement procured by the Contractor, shall, after delivery at Site and at the discretion of the Employer, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes.

4.1.5.3 Rejection

The Employer may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective shall not be used and shall be promptly removed from the site by the Contractor.

4.1.6 Steel

4.1.6.1 General

All steel bars, sections, plates and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction

specifications such as dimensions, shape, weight, tolerances, testing, etc. for all materials covered under this section, shall conform to respective IS Standards.

4.1.6.2 Reinforcement Bars

Reinforcement bars to be used for civil and structural works shall be low alloy steel of grade Fe 500 D confirming to IS:1786.

Reinforcement steel shall be purchased only from Integrated Steel Plant.

4.1.6.3 Structural Steel

Structural steel to be used for general structural purposes shall be of grade A conforming to IS:2062.

Structural steel sections shall conform to following IS specifications.

Steel tubes for structural purposes	IS:1161
Mild Steel Tubes, tubulars and other wrought steel fittings	IS:1239
Hollow steel sections for structural use	IS:4923

4.1.6.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following IS specifications.

Expanded Metal Steel Sheets for General purposes	IS:412
Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I) (for mild steel bars of anchor bolts, rungs, metal inserts, grating etc.)	IS:432
Hexagonal head bolts, screws & nets of product grade C	IS:1363
Cold formed light gauge structural steel sections	IS:811
Technical supply conditions for threaded steel fasteners	IS:1367
Plain washers	IS:2016
Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes	IS:2315
Bulldog grips	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fillings. (for Hand rail tubular sections).	IS:1239
Drop forged sockets for wire ropes for general engineering purposes	IS:2485
Steel chequered plates	IS:3502
Hexagonal bolts and nuts (M42 to M150)	IS:3138

- Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS Codes mentioned above.

4.1.6.5 Storage

The storage of all materials at site of work shall be at the Contractor's expense and risk and shall be done as per the requirements given in IS:4082. The Contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Employer for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel materials etc., shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping.

4.1.6.6 Tests after Delivery

Materials procured by the Contractor, shall, after delivery at site and at the discretion of Employer, be subjected to any or all of the tests, required by the relevant IS Codes. The Contractor shall carry out and bear the cost of such tests. The Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

4.1.6.7 Rejection

The Employer may reject at his direction any material, notwithstanding the manufacturer's certificate, failing to meet the requirements of relevant IS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and has to be removed from the site by the Contractor at his own expense.

4.1.7 Bricks

4.1.7.1 General

Bricks for masonry works shall conform to IS:1077–Specification for common burnt clay building bricks and shall be of class 7.5 (with minimum compressive strength of 7.5 N/mm^2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the Contract for a particular site or type of work. Physical requirement, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS:1077.

Bricks shall be hand-moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

4.1.7.2 Tests after Delivery

The Contractor shall make samples of each type of brick as directed by the Employer as per the requirements of IS: 5454 and tests shall be carried out as per IS: 3495. The cost for carrying out any or all the tests shall be borne by the Contractor. The bricks, when tested, as per IS: 3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved shall be deposited with the Employer. All subsequent deliveries shall be upto the standards of the approved samples.

4.1.7.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to

the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

4.1.7.4 Local Bricks

Where shown on drawings, locally available bricks of non-modular size (230 mm x 115 mm x 75 mm) in place of bricks of modular size (190 mm x 90 mm x 90 mm) can be used in case the bricks satisfy the other requirements of IS: 1077.

4.1.8 Stones

4.1.8.1 General

All stones used for masonry works shall conform to the requirements of following IS Codes.

Method of identification of natural building stones	IS:1123
Recommendations for dimensions and workmanship of natural building stones for masonry work	IS:1127
Recommendations for dressing of natural building stones	IS:1129

4.1.8.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed 3/4th thickness of the wall. Height of the stone shall not be more than 300 mm.

4.1.8.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate stop for drainage. The supply of stones shall be so arranged that as far as possible, at least two day's requirements of stone are available at site of at any time.

4.1.9 Admixtures

4.1.9.1 General

All concrete admixtures shall in general comply with the following Indian standards unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds: IS:2645
- Specification for other admixtures for concrete : IS:9103

Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Employer may require the Contractor to carry out and submit any or all the tests (as specified in relevant IS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the Contractor shall submit to the Employer the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from recognised and approved laboratories or any other document directed by the Employer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer for his selection. In case, both the names are rejected, the Contractor shall submit a fresh list of two manufacturers for approval by the Employer.

The Employer may direct the Contractor to submit test results as required by IS:2645 or IS:9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any IS code for testing and acceptability criteria, relevant British, American or German Code shall be applicable in the order of preference.

Prior approval of the Employer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless prior approval taken from the Employer. Once approved, utmost care shall be taken at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in IS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water cement ratio of the Design Mix during execution.

The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

4.1.9.2 Water Proofing Compounds

The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case it shall exceed 3% by weight of cement.

The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS: 4031.

Compressive strength of specimen at 3 days shall not be less than 270 kg/sq.cm. nor 90% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly compressive strength at 7 days shall not be less than 370 kg/sq.cm. nor less than 90% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS: 4031.

4.1.10 Water Bars (Water Stops)

PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. This shall be able to withstand a water head of at least 12 metres.

Performance requirements of PVC water bars shall meet the requirements of IS:12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness shall not be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

4.1.11 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant IS Codes as given below:

Specification of Paving Bitumen	IS:73
Specification for bitumen mastic for flooring	IS:1195
Specification for bitumen felts for water proofing and damp proofing	IS:1322
Specification for Bituminous compounds for water proofing and caulking purposes	IS:1834
Specification for preformed fillers for expansion joint in concrete pavements and structures	IS:1838
Specification for bitumen mastic for use in water proofing of roofs	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing	IS:5871
Specification for Glass fibre base coal tar pitch & bitumen felts	IS:7193
Code of practice for damp proofing using bitumen mastic	IS:7198

Specification for bitumen Mastic, Anti Static and electrically conducting grade	IS:8374

The type and grade shall be as shown on the drawings or as directed by Employer. Tests and acceptable criteria shall be as per relevant IS Codes.

4.1.12 PVC Pipes

PVC Pipes shall conform to the requirements of IS:4985.

4.1.13 Wood/Timber

Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements of IS:4082.

For proper identification and selection of suitable timber for formwork, following codes shall be referred.

Classification of commercial timbers and their zonal distribution: IS:399

Specification for ballies for general purposes : IS:3337

Specification for ply wood for concrete shuttering work : IS:4990

4.1.14 Paint

4.1.14.1 General

All paints shall be of an approved quality and shall be obtained from only those suppliers and makers who have been in the market for a period of not less than 5 years. All paints shall conform to the appropriate Indian Standards for ready mixed paints where applicable. All paints, undercoats, primers and finishing paint shall be supplied in sealed container. The Engineer may, if he so wishes, take samples for analysis at the Contractor's expense.

Wood preservative shall be of chemical type comprising copper-chrome-arsenic composition conforming to IS 401-1967.

All paints shall be stored in cool and dry conditions and clear of other stores to the approval of the Engineer.

4.1.14.2 Painting

All structural steel work and metals including handrails, brackets & exposed surfaces of steel inserts shall be painted except if otherwise specified.

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Parts I & II) "Code of Practice for Painting of Ferrous Metals in Buildings" except in so far as this Specification modifies it.

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 21/2 by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access. All painting shall be carried out by brushing. Spray and roller application of paint shall not be allowed without the written permission of the Engineer.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted,

they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Engineer.

All steelwork unless specified otherwise, shall be painted as per the following schedule:

1. Surface preparation and coating for under water / splash zone
   a) Surface preparation SA-2.5 with profile 50-70 micron.
   b) Modified High Build glass flake epoxy with more than10 % glass flake content in dry film. DFT min 400 (2 x 200) micron with tolerance ±10%,-0
2. Without contact in water on Jetty
   a) Surface preparation SA-2.5 with profile 50-70 micron.
   b) Modified High Build glass flake epoxy with more than10 % glass flake content in dry film. DFT min 400 (2 x 200) micron
   c) Top coat acrylic aliphatic PU – 70 (35 x 2 coats) micron
      Total DFT min 470 micron with tolerance ±10%,-0
3. Backup area far from jetty
   a) Surface preparation SA-2.5 with profile 50-70 micron.
   b) Primer –ethyle zinc silicate with zinc content in dry film minimum 85% , level I Type II – 75 micron or zinc rich epoxy primer with zinc content in dry film minimum 85% - 75 micron and second coat High Build epoxy MIO 150 micron + top coat – acrylic aliphatic PU 70 micron
      Total DFT minimum 295 micron with tolerance ±10%, -0
4. Hand rail, gratings shall be hot dip galvanized up to 5 mm 610 GSM , above 5 mm 910 GSM fasteners shall be hot dip galvanized 80-100 micron. After hot dip galvanizing the material shall be surface cleaned by solvent / mechanical power tool and then primer pure epoxy -50 micron, surface tolerant epoxy -100 micron, top coat PU -50micron, total DFT excluding galvanizing coating 200 micron minimum.

Touchup primer with MIO and aluminium pigment shall be used for repair wherever applicable. In case of major damage of original coating system, surface preparation and coating same as original system shall be strictly followed.

In case of minor repair of subsequent coats damage, touchup primer surface tolerant with MIO and aluminium pigment shall be applied. Coating of touch up primer shall be as per manufacturer's recommendations, before procurement of painting product client approval is mandatory.

Contractor shall submit surface preparation and painting procedure for client approval.
Surface should be salt free, maximum acceptable value is 5 micro gram/cm^2
Adhesion value is minimum–X cut 4A, pull out /dolly minimum 5 MPa.

Guarantee of coating performance – minimum 5 years maintenance free.

Final colour shade shall be applied as per client recommendation

Approved coating manufacturers - Akzonoble /Jotun/Hempel/Sigma PPG
During surface preparation and painting, paint manufacturer, technical NACE /BGAS minimum level II qualified and minimum 10yrs experience should be deployed for full time inspection and coating quality certification.

During surface preparation and coating, weather condition shall be controlled such as substrate temperature, humidity, maximum weather temperature. Storage of paint shall be stored as per paint manufacturer recommendation

Painting shall be done by airless spray gun / brush/ Roller as per instruction of client engineer or recommendation of NACE/ BGAS quality paint manufacturer.

For surface preparation, recommended size of copper slag 0.5 to 2micronm. For SS, surface shall be blasted with garnet with profile 40-50 micron and coating system shall be same as mentioned above for hot dip galvanizing surface.

Painting on fasteners shall be done after torque tightening.

Reference / applicable code & standards:

- Paint manufacturers instruction & safety data sheet
- Technical data sheet for paints / touch –up paints systems
- Surface preparation and coating / painting shall be carried out in accordance with project technical specification
- ISO 12944
- ISO 8501
- ASTM- D- 3359
- SSPC – PA.2
- ISO 850 A
- ISO-8502

4.1.15 Polysulphide Sealants

All Polysulphide Sealants shall conform to IS: 12118 and be of approved made. Test conditions and requirements shall be as given in the above referred IS code.

4.2 Plain and Reinforced Concrete Works

4.2.1 General

The section of the specifications includes requirements for furnishing and placing all plain and reinforced cement concrete including form work, reinforcement and incidental works required for the completion of this Contract and herein specified.

This specification establishes the materials, mixing, placing, curing, etc. of all types of cast-in-situ and precast concrete used in jetty, approach trestle, retaining walls, underground structures, floors, buildings, etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

4.2.2 Materials

Materials for concrete viz cement, sand, coarse aggregate, water, etc. shall be as described in under specification of 'Materials'.

Materials for all reinforcements, embedment, inserts, water bars, etc. shall conform to specification of 'Materials'.

4.2.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per Table 1.

Table 1 – Grades of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm2)
M 15	15
M20	20
M25	25
M30	30
M35	35
M40	40

The characteristic strength is defined as the strength of material, below which not more than five (5) percent of the test results are expected to fall.

4.2.4 Type of Concrete Mix

Unless otherwise noted all lean and reinforced concrete shall be nominal mix and design mix types respectively.

4.2.4.1 Nominal Mix Concrete

The Nominal Mix Concrete shall not be used. Only Design Mix concrete shall be used. Hand mixing of cement/sand mortar for use in plastering shall not be allowed. All such mixing shall be done through mechanical mixer only.

4.2.4.2 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table 1 above.

As long as the quality of materials does not change, a mix design done earlier shall be considered adequate for later work. However, in case the quality of materials changes, the Employer may ask for a new design mix.

While designing the mix, the durability requirements as given in IS:456 shall also be taken into account.

4.2.5 Concrete Mix Proportioning

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required strength, workability, durability and other properties.

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS: 10262.

4.2.5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The Contractor shall submit to the Employer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

4.2.5.2 Water-Cement Ratio

Once a mix, including its water-cement ratio, has been determined and approved for use by the Employer, that water-cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water-cement ratio. Maximum water-cement ratio shall never exceed the values given in IS: 456 and IS: 4651 for various exposures and sulphate attack conditions from durability considerations.

4.2.5.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

4.2.5.4 Workability

The concrete mix proportion shall be such that the concrete is of adequate workability for the placing condition and can be properly compacted with the means available. Use of plasticiser / super-plasticiser of approved make shall be taken recourse to where required for attaining proper workability as specified in Table 2 below. However, prior written approval of the Employer shall be obtained for any such use of plasticiser / super-plasticiser before submitting the proposed design-mix for approval. Where adequate workability is difficult to obtain at maximum permissible water-cement ratio, increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS: 1199 are indicated in Table 2 below. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and shall be got approved by the Employer.

Table 2 - Values of Workability

Placing conditions	Degree of workability	Values of workability
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 compacting factor
Heavily reinforced sections with vibration	Medium	5-2 seconds vee-bee time or 0.89-0.92 compacting factor or 25-75mm slump for 20mm aggregate

4.2.5.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as per standard codes. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in Table-2A.

Table 2A - Minimum Cement Content and Maximum Water Cement Ratio for Durability

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content (Kg./m^3)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg./m^3)	Maximum Water-Cement Ratio
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note:

1. Severe exposure shall include structures exposed to sea or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO3 content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as CI) content exceeding 1500 ppm in ground water or soil shall be considered as severe exposure condition.
2. Structures subjected to aggressive environment below the minimum limits expressed in Note-1 above and/or those in industrial/chemical plants atmosphere shall be considered under moderate exposure. Also, any concrete structure in contact with water or retaining water or any other liquid not usually harmful to concrete shall be considered under moderate exposure.

3. All other environmental conditions not covered under Notes-1&2 shall be categorised under Normal exposure.

* OPC - Ordinary low heat Portland Cement
* PPC - Portland Pozzolana Cement
* PSC - Portland Slag Cement
* SRC - Sulphate Resistant Cement
* SSC - Super Sulphated Cement

4.2.6 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. Batching plant, where used, shall conform to IS: 4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy periodically checked.

Except where it can be shown to the satisfaction of the Employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer to ensure that the approved grading is maintained.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS: 2386 (Part-111) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table-3.

Table 3 - Surface Water Carried by Aggregate

Aggregate	**Approximate Quantity of Surface**	
	Percent by mass	**Litre / m^3**
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the Employer and his approval has to be obtained prior to using the revised

mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

4.2.7 Concrete Mixing

Concrete shall be produced in Concrete Batching Plant. The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation, after unloading from the mixer, the concrete shall be remixed.

4.2.7.1 Mixer

Mixers shall comply with IS: 1791 and shall be maintained in satisfactory operating condition. Mixer drum shall be kept free of hardened concrete and blades shall be replaced when worn down more than ten percent (10%) of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause waste of materials, its use shall be promptly discontinued until it is repaired.

4.2.7.2 Mixing Time

Mixing time shall be as indicated in the following table. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer may, however, direct a change in the mixing time, if he considers such a change necessary.

Capacity of mixer	Minimum Mixing time
2 m^3 or less	1½ minutes
3m^3	2½ minutes
5m^3	3 minutes

All records and charts for the batching and mixing operations shall be prepared and maintained by the Contractor as per the instructions of the Employer.

4.2.7.3 Deleted

4.2.7.4 Admixtures

Admixtures in concrete shall be used only with the prior approval of the Employer. Any admixture used for obtaining proper workability or leak-proof-ness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for.

4.2.8 Transportation, Placing and Compaction

The entire concrete placing programme including transportation arrangements, deployment of equipment, lay out, proposed procedures and methods, shall be submitted to the Employer 24 hours prior to concreting, for approval. No concreting shall be placed until his approval has been received. Approval of the Employer for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

4.2.8.1 Placing of Concrete

Placing of concrete shall be carried out by use of pump, placer boom, conveyor or crane and bucket etc. subject to approval of Engineer-in-Charge.

4.2.8.2 Vibrators

Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 and 12,000 vibrations per minute. All vibrators shall comply with IS:2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS:2506, 2514 and 4656, respectively, shall be used where specifically required and directed by Employer.

Immersion type vibrators shall be inserted in a vertical position at intervals of about 600mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Employer.

In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Employer.

The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However for thin slabs (of thickness less than 200mm) surface vibration by such vibrators may be permitted, upon approval of the Employer.

Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

4.2.8.3 Transportation

All concrete shall be conveyed from the mixer to the place of final deposit as rapidly as possible in suitable buckets with crane, dumpers, boom placers, pumps or conveyors, which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

4.2.8.4 Placing and Compaction

Before placing concrete, all surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete.

Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts, pockets etc. have been inspected and approved by the Employer. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface.

Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5m throughout all stages of delivery until the concrete comes to rest in forms. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shovelling. Any tendency to segregation shall be corrected by shovelling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Employer.

All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Employer. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Employer.

The method of placing and compaction employed in any particular section of the work shall be as per direction of the Employer.

During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius), the concreting shall be done as per the procedure set out in IS:7861. Concrete that has set standing and becomes stiffened shall not be used in the work.

Formation of cold joints shall be avoided.

4.2.8.5 Items Embedded In Concrete

Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and

maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Employer.

Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Employer.

All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the approval of Employer so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

4.2.9 Construction Joints

Construction joints shall be provided in position as described in the drawings or as directed by the Employer. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement.

When the work has to be resumed on a surface, which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgment of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

4.2.10 Separation Joint

Separation joint shall be obtained by using an approved alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

4.2.11 Expansion Joints/Isolation Joint

Expansion/Isolation joints in structures shall be formed in the positions and to the required shapes. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches, etc. on grade.

4.2.12 Water Stops

PVC water stops as per specifications under ‘Materials’ shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/ construction joints.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

4.2.13 Protection of Freshly Laid Concrete

Newly placed concrete shall be protected, by approved means, from rain, sun and wind.

4.2.14 Curing

Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose,sprinklers etc. A layer of sacking, canvas, hessian, or other approved material,which will hold moisture for long periods and prevent loss of moisture from the concrete,shall be used as covering. Type of covering which would stain, disfigure, or damage the concrete, during and after the curing period,shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete, except that high early strength concrete shall be so maintained for at least the first 3 days.

The Contractor shall have all equipment and materials required for curing on band and ready to use before concrete is placed.

For curing the concrete in pavements, the ponding method of curing is preferred after the expiry of first 24 hours during which (i.e. first 24 hours) the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained . The method of containing the ponded water shall be approved by the Employer. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to future finishes.

4.2.15 Field Tests

4.2.15.1 Grading Test

Grading test on fine and coarse aggregates shall be carried out as per IS:2386 at intervals specified by the Employer.

The mandatory tests and their frequencies shall be done on sand and stone aggregates as given in Table-4.

Table-4: Mandatory Tests on Sand & Stone Aggregates

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carrying out the Test	Frequency of Testing
1	Sand	a) Bulking of Sand	Field	20m^3	Every 20 m^3 or part thereof or more frequently as decided by the Employer
		b) Silt content	Field	20m^3	-DO-
		c) Particle size distribution	Field or Lab as decided by the Employer	40 m^3	l)Every 40 m^3 of fine aggregate/ sand required in RCC works only 2)Every 80 m^3 of fine aggregate/sand required for other items
2	Store aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by the Employer or as specified	As required by Engineer	For all quantities
		b) Particle size distribution	Field or lab as required by Employer	45 m^3	For every 45 m^3 or part thereof as decided by Employer
		Ten percent Fine value	Laboratory	45m^3	Initial test and subsequent test as & when required by Employer.

4.2.15.2 Vee-Bee Test/Slump Test of Concrete

At least one Vee-Bee Test/Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Employer.

4.2.15.3 Strength Test of Concrete

Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS:516.

In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72+2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in Table 5 may be taken for general guidance in the case of concrete made with ordinary Portland cement. In all cases, the 28 days compressive strength specified in Table 1 shall alone be the criterion for acceptance or rejection of the concrete from strength consideration.

Table-5 - Test Requirement of Concrete

Grade of Concrete	Compressive strength on 15 cm cubes minimum at 7 days (N/mm^2)	Moduolus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm^2)	7 days (N/mm^2)
M15	10.0	1.5	2.1
M20	13.5	1.7	2.4
M25	17.0	1,9	2.7
M30	20.0	2.1	3.0
M35	23.5	2.3	3.2
M40	27.0	2.5	3.4

4.2.15.4 Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested, that is the sampling should be spread over the entire period of concreting and cover all mixing units.

4.2.15.5 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with the following:

Quantity of concrete in the work in m3	Number of samples
1-5 6-15 16-30 31-50 51 & above	1 2 3 4 4 plus one additional sample for each additional $50m^3$ or part thereof
NOTE: At least one sample shall be taken from each shift.	

4.2.15.6 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS:9013. The specimen shall be tested as described in IS:516.

4.2.15.7 Test Strength of Sample

The test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than±15percent of the average.

4.2.15.8 Standard Deviation

i) Standard deviation based on test results:

a) Number of test results: The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less

than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time.

b) Standard deviation to be brought up to date: The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month.

ii) Determination of Standard Deviation:

a) Concrete of each grade shall be analysed separately to determine its standard deviation.

b) The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that grade obtained as specified in 2.1.11

Estimated standard deviation(s) = $\sqrt{\frac{\sum \Delta^2}{n-1}}$

Δ = deviation of the indiviaual test strength from the average strength of n samples

n =number of sample test results

c) When significant changes are made in the production of concrete | batches (for example changes in the materials used, mix design, equipment or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

iii) Assumed Standard Deviation: Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 6 may be assumed.

Table 6 - Assumed Standard Deviation

Grade of Concrete	Assumed Standard Deviation (N/mm^2)
M 15	3.5
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6

However, when adequate past records for a similar grade exist and justify to the Employer, a value of standard deviation different from that shown in Table 6, it shall be permissible to use that value.

4.2.15.9 Acceptance Criteria

The acceptance criteria for concrete shall be as per IS456:2000. Concrete shall be assessed daily for compliance.

Concrete is liable to be rejected if it is porous or honey-combed; its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met or crack width has exceeded permissible limit.

4.2.16 Inspection and Testing of Structures

4.2.16.1 Inspection

Immediately after stripping the formwork, all concrete shall be carefully inspected and defective work or small defects, if any, shall either be removed or made good before concrete has thoroughly hardened.

4.2.16.2 Testing of Structures or Parts of Structures

In case the results of work test cubes do not comply with the specified strength requirements or there is reasonable doubt regarding the strength of concrete used, either due to poor workmanship or materials the Employer may instruct the Contractor to perform additional tests as Employer feel necessary and/or load test as specified in Clause 4.2.16.3 to ascertain the quality of concrete. These tests shall also be required to be carried out in the event the Employer is doubtful regarding the adequacy of strength of the structure due to suspected overloading during construction, premature removal and non-conformance to specification of formwork, improper curing or any other reason. The number and type of tests to be carried out shall be determined by the Employer whose decision shall be final and binding on the Contractor.

4.2.16.3 Load Test

Load test, where directed by the Employer, shall be carried out as soon as possible after expiry of 28 days from the time of placing of concrete. The structure shall be subjected to a load equal to full dead load of the structure (which shall include Self Weight of Structural members plus weight of finishes) plus 1.25 times the imposed load (for which the structure has been designed) for a period of 24 hours and then the imposed load shall be removed. The deflection due to imposed load only shall be recorded. If within 24 hours of removal of the imposed load the structure does not recover at least 75percent of the deflection under imposed load, the test shall be repeated after a lapse of 72 hours. If the recovery is less than 80percent, the structure shall be deemed to be unacceptable.

If the maximum deflection in mm, shown during 24 hours under load is less than 40 L^2/D, where L is the effective span in meters and D the overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provision as given above shall not apply.

The Employer shall be the final Employer for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Employer shall be final and binding on the Contractor. In case the results of the tests are unsatisfactory, the Employer may instruct the Contractor to demolish and reconstruct the structure.

4.2.17 Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Employer. The Employer may at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However,if honey-combing or sagging are of such extent as being undesirable, the Employer may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as

from the formwork except that honey-combed surface shall be made good as specified above.

4.2.18 Cement Wash

If instructed by the Employer, the Contractor shall provide one coat of cement wash over the exposed concrete surfaces of foundations, beams, columns, walls, lintels, soffit of slabs etc. which are not plastered and appearance-wise not up to acceptable standard. No extra amount shall be paid to the Contractor on this account.

4.2.19 Form Work

4.2.19.1 General

Forms for concrete shall be of plywood conforming to IS:6461 or steel or as directed by the Employer and shall give smooth and even surface after removal thereof.

If it is desired by the Employer, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Employer.

Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Employer shall be final and binding in this regard.

a) Deviation from specified dimensions: -6mm to +12mm of cross section of columns & beams

b) Deviation from dimensions of footings (see Note below)

   i) Dimensions in plan : -12mm to +50mm

   ii) Eccentricity : 0.02 times the width of the footing in the direction of deviation but not more than 50 mm.

   iii) Thickness : ±0.05 times the specified thickness.

   Note: Tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

c) Deviation in length (major dimension of single unit)

   i) Upto 3m : $\pm$ 6mm

   ii) 3m to 4.5m : $\pm$ 9mm

   iii) 4.5m to 6m : $\pm$ 12mm

   Additional deviation for every subsequent 6m: $\pm$ 6mm

d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

   i) Upto 3m : 6mm

   ii) 3m to 6m : 9mm

   iii) 6m to 12m : 12mm

   iv) Additional for every subsequent 6m: 6mm

e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

f) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

- upto 600mm wide and upto 6m in length: - 6mm
- over 600mm wide and for any length: - 12mm

Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

4.2.19.2 Form Requirement

The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete working load, wind load and also the side pressure exerted by the green concrete. As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

Tie wires shall be permitted only upon approval of the Employer and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in Clause 4.2.17.

Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be $1/100^{th}$ of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Employer.

All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in Table 7 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 7 - Minimum Design Pressure for Wall Formwork

Rate of pour in meter/hour	Pressure in kN/m^2	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/Sqm.

4.2.19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Employer before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been corrected as per the instructions of the Employer.

4.2.19.4 Treatment of Forms

The surfaces of forms that would come in contact with concrete shall be well treated with approved non- staining release agents such as soft soap, oil, emulsions etc. Care shall be taken that such releasing agents are kept out of contact with the reinforcement.

4.2.19.5 Chamfers and Fillets

All comers and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfer and fillets, unless otherwise detailed or specified shall be 25x25mm. For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

4.2.19.6 Reuse of Forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Employer.

4.2.19.7 Removal of Forms / Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Employer. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 16 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

a)	Walls, columns and vertical	:	24 to 48 hours may faces of all structural members be decided by the Employer
b)	Slabs (props left under)	:	3 days
c)	Beam Soffits (props left under)	:	7 days
d)	Removal of props under slabs	:	
	- Spanning upto 4.5m.	:	7 days
	- Spanning over 4.5m.	:	14 days
e)	Removal of props under beams and arches:		
	- Spanning upto 6m.	:	14 days
	- Spanning over 6m and upto 9m	:	21 days
	- Spanning over 9m.	:	28 days
f)	Cantilever Construction	:	Formwork shall remain till structures for counter-acting or bearing down have been erected & have attained sufficient strength (minimum 14 days).

Notes:

1. ***For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 24 hours.***
2. ***For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Employer.***
3. ***The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.***
4. ***Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.***

4.2.19.8 Staging / Scaffolding

Staging / Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Employer before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

a) Sufficient sills or under pinnings in addition to base plates shall be provided particularly where scaffolding are erected on soft grounds.

b) Adjustable bases to compensate for uneven ground shall be used.

c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

d) Horizontal braces shall be provided to prevent the scaffolding / staging from rocking.

e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

f) The scaffolding / staging shall be checked at every stage for plumb line.

g) Wherever the scaffolding / staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil Engineer of the Contractor.

For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding / staging by the Employer at his sole discretion. The Contractor must ensure the safety and suitability of such works as described above.

4.2.20 Exposed Concrete Work

4.2.20.1 Form Work

Other things remaining same as per Clause 4.2.19, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the Contractor's drawings. The forms shall be butting with each other in straight lines, the comers of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the Contractor's drawings. Maximum care shall be taken to make the formwork watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work for exposed concrete work as specified below.

Such reuses shall be permitted only if forms are properly cared for, stored, repaired and treated after each use.

a) Plywood Forms : 6 Reuses (Max.)

b) Steel Forms : 10 Reuses (Max.)

However in case of steel formwork higher number of reuses could be permitted as long as casting tolerance levels are within acceptable limits.

The Employer may, at his absolute discretion, order removal of any forms considered unfit for use in the work irrespective of the number of uses specified above.

4.2.20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done.Minor repairing, if unavoidable shall be done as specified in Clause 4.2.17 with the written permission of the Employer.

4.2.20.3 Reinforcement

General

Reinforcement shall be cut,bent to shape and dimensions as shown in the Contractor's bar bending schedules/drawings. In normal course the bar bending schedule of selected structures/structural parts shall be supplied to the Contractor.

Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS:2502.In case bars are supplied in coils,they shall be smoothly straightened without any kinks.

Bars shall be bent in a slow and regular movement to avoid fractures. Bars which develop cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position,care should be taken to ensure that at no time is radius of the bend less than 4 times bar diameter for plain mild steel or 6 times bar diameter for high strength deformed bars.Care shall also be taken when bending back bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

4.2.20.4 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.

The reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire confirming to IS:280. Crossing bars shall not be tack welded for assembly of reinforcement. Knots in the winding wire shall be placed inside & not in cover Zone. The reinforcement bars shall be kept in position by using the following methods:

a) In case of beam and slab construction, precast cover blocks (having the same cement sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

   When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

4.2.20.5 Splicing / Overlapping

Only bars of full length shall be used. But where this cannot be done, overlapping of bars shall be done as directed by the Employer. Where practicable, the overlapping bars shall not touch each other, but these shall be kept apart by 25mm or 1.25 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

4.2.20.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Employer. Where welding is permitted, it shall be in accordance with the recommendations of IS:2751 and IS:9417.Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Employer to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

4.2.20.7 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used {as per manufacturer's specifications) with the written approval of the Employer. However, tests shall be made as directed by Employer to prove that such connections are of the full strength of the bars on trial joints.

4.2.20.8 Tolerances

Unless otherwise directed by the Employer, reinforcement shall be placed within the following tolerances:

a) For effective depth 200mm or less : ± 10mm

b) For effective depth more than 200mm: ±15mm

The cover shall in no case be reduced by more than one third of specified cover or 5mm, whichever is less.

4.2.20.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Employer.

4.2.20.10 Cover

Cover to reinforcement shall be as per standard codes / as directed by the Employer.

4.2.20.11 Precast Concrete

Specifications contained in above regarding concrete, formwork and reinforcement shall apply in addition to the specification given as under. The Contractor shall get the pre-casting bed approved by the Employer.

Necessary lifting hooks of suitable (but not less than 12mm dia) diameter M.S. rounds shall be provided for handling.

Unless otherwise specified, the exposed surfaces of precast members shall be integrally finished smooth. Scheme for precasting, curing, handling, storage and placing in final position shall be prepared by the Contractor in advance and got approved by the Engineer.

The precast concrete units shall be marked clearly on top surface with the letter "T" for identification of surfaces at the time of erection and shall be stored properly until required for erection. The precast units shall be handled and erected by methods approved by the Employer to protect them from damage.

The Contractor shall take all necessary precautions for safe handling during the course of erection. The Contractor shall replace all such units, which are damaged during the course of erection.

4.2.21 Concrete Underwater

Where concrete is to be deposited underwater, the greatest care shall be taken to prevent the cement being washed out. The concrete shall be placed through a tremie pipe with suitable hopper and plunger arrangements. Great care shall be taken to ensure that no segregation of concrete takes place and the Employer shall approve the method of placing.

The discharge end of the tremie tube shall plugged at the start of the work so as to minimise the entry of water into the tube and it shall be entirely sealed at all times and kept full of concrete upto the bottom of hopper. Concreting operations once commenced are to be completed in full without break otherwise the structure shall be considered as rejected.

4.2.22 Underground Concrete Work

All reinforced concrete work below ground level or other filled areas shall be protected from the aggressive action of salts and other chemicals contained in all types of earth and rocks, ground water or other materials as follows:

i) Except where otherwise agreed by the Employer, the underside of all concrete foundations, beams, slabs, ducts, manholes, shall have a layer of at least 75 mm of blinding concrete of an approved mix using sulphate resistant cement. The top face to be finished to take the polythene sheeting material.

ii) A layer of polythene sheeting material shall be laid prior to concreting under the foundations, beams, slabs, ducts, manholes, etc. and carried up the sides of such members to ground level or other level as defined by the Employer. Laps in the polythene sheeting material shall not be less than 300 mm and securely taped as specified.

Care shall be taken to avoid puncturing or tearing the sheeting and should this occur the puncture or tear shall be repaired to the approval of the Employer or the sheeting replaced.

i) The surfaces of concrete exposed after the removal of form including top faces of buried members shall be painted with one coat of primer (Bituminous solvent) and two coat of Bituminous (blended together with non-asbestos reinforcing fabric and solvent) applied as manufacturer's instructions and to the approval of the Employer.

ii) The external surfaces of manholes, cable pits and service pits shall be coated with two coats of a rubber reinforced bitumen emulsion, brush applied. The coatings shall be applied strictly in accordance with the manufacturer's instructions.

4.2.23 Concreting in Inclement Weather

In the event of rainstorm or any other severe conditions arising, concreting shall be stopped and appropriate temporary stop ends, vee grooves, etc. placed as may be necessary. During wet weather, the concrete shall be adequately protected as soon as put into position.

The Contractor shall always have in readiness approved framed sheeting, tarpaulin etc. for the protection of newly placed concrete during inclement weather. Shall any concrete be damaged due to rainstorms or other weather conditions, the Employer may order the cutting out and replacement of the damaged concrete.

4.2.24 Grouting

The base plates of all the steel structures shall be grouted to thickness as shown on the relevant structural drawings of Contractor, after the alignment and approval of the Employer. The grout shall consist of either

a) 1:2 (1 Cement: 2 Sand) mortar for operating platforms (not supporting Equipment), pipe supports upto 2.5m in height (above concrete top), cross-over, stair cases and ladders. or

b) Free flow non shrink Grout (Pre-mix type) of compressive strength not less than 40/mm^2 for all structures other than those covered in (a) above, as per the instructions / recommendations of the manufacturer.

4.2.25 Continuous Concreting

Continuous concreting shall be done in a single operation as per the requirements of IS:456 and IS:2974. It shall be ensured that Clause 4.2.8.4 of these specifications is not violated in case of continuous concreting. Sufficient "Windows" shall be left in the formwork for walls, columns and other thin sections of significant height for pouring& compaction of concrete and inspection. The concrete to be placed in a manner that will prevent segregation and accumulation of hardened concrete on the formwork or reinforcement above the level of the placed concrete. These windows shall be fixed tight once the level of concrete reaches their levels.

4.3 Pile Foundations

4.3.1 General

This section of specification includes requirement for furnishing and placing/installation of reinforced concrete bored cast in-situ piles.

4.3.2 Bored cast in-situ Piles

4.3.2.1 General

Piles may be of any type as may be designed by the Contractor for the works or any part thereof. However concrete bored cast in-situ pile types are described in brief.

The Contractor shall furnish materials, labour and equipment necessary to drill or bore and install bored piles in accordance with this specification.

Unless specified the grade of concrete shall be minimum M40 conforming to IS:10262. The cement content for piling work shall be minimum 400 kg/m^3 and maximum water cement ratio shall be 0.45.

The properties of cement, reinforcement and fine/coarse aggregates to be used for piles construction shall be in accordance with the specifications under ‘Materials’.

For piles Permanent MS casing / Liner upto its required levels shall be provided and the minimum thickness of the MS Liner shall be 8 mm.

Construction of bored piles shall be carried out in accordance with the relevant sections of IS:2911 (Part I/sec 2) and initial & routine pile load test shall be conducted as per IS:2911 (Part 4) except where otherwise specified, described or directed by the Employer.

4.3.2.2 Programme and Method of Construction

The Contractor must furnish to the Employer, before commencing work, a detailed method of construction he intends to adopt for piling work together with the programme of construction.

4.3.2.3 Boring

Boring shall generally be carried out by procedure as set out in IS 2911 (Part 1/Sec 2)by Hydraulic Rotary Rigs using temporary or permanent casing as required and drilling mud for

bore stabilization including flushing /cleaning of pile bore. If the soil is found to be unstable, the boring tools should be such that suction effects are minimized. Walls of boreholes shall be stabilized by using removable bottom casings with or without drilling fluid depending upon the soil conditions. In soils liable to flow, the bottom casing should be kept ahead of the boring in all cases to prevent the entry of soil into the bore, so preventing the formation of cavities and settlements in the adjoining ground. Continuous pumping shall not be used for excavating inside the boreholes. While below sub-soil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to the difference in hydrostatic head. No percussion equipment is to be used unless rock strata is encountered. The size of cutting tool shall not be less than the diameter of pile by more than 75 mm.

Where stabilization of the sides of the boreholes is effected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5 m above the level of the sub-soil water or high water level as the case may be and the hole shall then always be kept almost full with it till the concreting is completed.

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from the boring in suspension.

Boring of any pile must be completed in one continuous operation without interruption. In case such interruptions are unavoidable, steps shall be taken to prevent the collapse of sides of the boreholes.

The Contractor shall be responsible in the event of bore collapse due to any reason, at the discretion of the Employer, re-boring or additional bores shall be carried out at no extra cost. If additional pile is driven and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

Boring in rock shall be carried out either by chiselling or by any other approved method. Cleaning bucket attached to the kelly shall be used for cleaning the bore. Wherever bentonite slurry is used, after using cleaning bucket, the bore shall be flushed with fresh bentonite slurry. Rock shall be classified in six grades I through VI in accordance with the classification made in BS 5930. Employer's interpretation in this context shall be final and binding.

The Contractor shall be responsible for the prompt removal from the Site of all spoil due to the boring up to a distance of 4 km and at places specified by the Employer. Also no muck, spoil, bentonite slurry or excavated soil shall be allowed to be discharged in river. The cost of such disposal shall be deemed to have been included in the price.

Foundation elevation of each pile will be individually approved by the Employer on the basis of the Employer satisfying himself, from observations, designs in supporting of the founding levels and all data including SPT tests at his disposal, of the soundness of the end bearing stratum. However, the piles shall be socketed minimum 1 (one) diameter into hard rock.

For determining the founding strata, standard penetration tests shall be carried out in the borehole by "Nordmeyer Standard Penetrometer" for 2 piles in every 50 m length of jetty, as decided by the Employer. Before commencing a penetrometer test, the bottom of the borehole shall be cleared.

4.3.2.4 Drilling Fluid

Bentonite used in the works shall be of the best quality. Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the pile excavation for the period, necessary to place concrete and complete construction. The fluid used shall be such as to form a suspension, which remains stable under the saline conditions likely to be encountered at the Site and suitable in all respects for the construction of piles.

Control test shall be carried out on the bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Employer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite used in the works.

Note:

Before selection of source test for bentonite powder shallbe made at external approved laboratory to satisfy requirements of relevant IS code. At site during piling work, tests on bentonite mud shall be made to satisfy requirements of IS 2911. At site, laboratory and other required facilities shall be made available.

Bentonite can be disposed as non-toxic and inactive materials in approved landfill sites in accordance with local regulations. Contaminated packaging can be disposed in approved landfill sites in accordance with local regulations.

4.3.2.5 Formation of Pile

The concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved and shall not be discharged freely into the water or drilling fluid. Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.15, the placing of concrete shall not proceed. In this event, the Contractor shall modify or replace the bentonite as directed by the Employer.

All equipment, material and operations employed in the formation of the piles shall be such as to ensure that the piles remain to the designed cross-section and shall be capable of carrying the specified test load 28 days after concreting.

The concrete shall be properly graded and well compacted without excess water, admixture of soil or other extraneous matter. The concrete shall be placed through a tremie pipe of 20 to 25 cm in dia. with a suitable hopper. The tremie pipes joints shall be airtight and hopper capacity shall be such that it produces a build-up of at least 2 m concrete in the pile. Great care shall be taken in the placement of the first pour using a suitable pig in the pour or a PVC plunger so that the concrete does not come in contact with water. The first pour is eventually brought up through successive pour of concrete and overflow at the end of concreting. The tremie pipe must extend down to the bottom of the borehole at the start and may be withdrawn in sections as the level of the concrete rises in the boreholes, but its discharge end shall at all times be immersed in the concrete to a minimum depth of one metre. Placing of concrete shall be continuous and the tremie pipe shall be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile.

At all stages of work every precaution shall be taken to prevent the formation of voids in the concrete caused by the faulty consolidation or pockets of air trapped within it. The volume of concrete placed shall be checked against calculated volume of pile at the time of placing. Any shortfall in actual consumption of concrete in pile shall not be more than 5% of the theoretical volume.

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few metres in order to note the difference, if any, between the theoretical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over – cut or caving in during boring.

Placing of concrete should be continuous and the tremie pipe should be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile. Concrete shall be placed and compacted until green concrete is obtained above the cut off level. Any excess concrete above cut off level will be dismantled neatly upto the cut off level, removing all cracked, loose and unbound concrete. Top surface of pile shall be kept rough. The cost of the same is presumed to be included in the rates and prices.

Capacity of pump to be used for cleaning of pile bore before concreting shall be not less than 40 H.P for piles of dia 1000mm / 1200 mm of 20 m depth and for higher sizes capacity would be decided by the Engineer.

4.3.2.6 Reinforcement

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to impede the placing of the concrete. They shall be placed correctly in position and be supported away from the sides of the pile shaft by means of spacer blocks to assume concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion or displacement. Care shall be taken to preserve the correct cover and the alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be as per I.S. Specifications. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level of the pile. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 m and wired to the main reinforcement.

4.3.2.7 MS Liners/Casing

For River piles (all Jetty piles deemed to be Jetty piles), permanent mild steel liner shall be provided for all piles from cut off level upto the required level depending on the soil conditions and/or as approved by the Employer. The minimum length should be provided 5m below the river bed level.

4.3.2.8 Control of Alignment

The pile shall be cast as accurately as possible to the vertical. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties shall, at the discretion of the Employer, be replaced or supplemented by additional piles at no extra cost. If any pile is deviated and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

4.3.2.9 Obstruction

If any obstruction is encountered, the installation shall cease and Contractor shall notify the Employer and submit for his approval, proposals for overcoming the difficulties. Notwithstanding any such approval, the Contractor will be entirely responsible for ensuring that the piles are completed to the required line, position and depth.

4.3.2.10 Volume Check

Concreting shall start as soon as possible after driving the liner or completion of boring. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles. If actual quantity is found to be considerably less, special investigation shall be conducted and appropriate measures taken.

4.3.2.11 Inspection

For bored piles, the Contractor shall have the Employer's inspection to the bore hole for proper plumb, location, compaction of founding surface, pressure of water and other requisites. The depth of the borehole shall be measured by means of a chain to which a plumb weighing not less than 100 g is attached. The Contractor shall provide all the equipment required for the above inspection and he shall co-ordinate this work with the Employer. Concreting shall start only after the Employer has approved the borehole. All facilities, equipment and labour required for inspection by the Employer mentioned above shall be provided by the Contractor promptly and free of cost.

4.3.2.12 Load Tests

Vertical load tests shall be carried out on the specially constructed test piles as per relevant IS codes. Initial load test by Static method/Reaction loading shall be carried out one on each diameter of land piles. Routine vertical load test by Static method/ Reaction loading shall be carried out one on each diameter of land piles In addition to vertical load tests, the Contractor shall carry out horizontal load test on bored piles specially constructed for the purpose as per relevant IS codes. Maximum test loads shall be as determined by the Employer according to I.S. Specifications considering the design horizontal loads.

One static load test shall also be carried out on a routine pile in river taking help from the adjoining permanent Piles/additional tension piles or installing soil anchors.

A) Vertical Load Test

a) The test shall be carried out by applying a series of loads on the test pile. The load shall be preferably applied by means of hydraulic jacks reacting against a symmetrically erected loaded platform which shall be preloaded to not less than 1½ times the design load carrying capacity of the pile. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote control pump.

   The Contractor shall arrange all the necessary equipment and kentledge with platform at his own expense well in advance of the load test. Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Employer for the latter's checking and approval.

b) The pile to be tested shall be chipped and dressed to a well-levelled surface. It is important that reinforcing bars of the pile do not project beyond the top surface of the level pile top.

   After preparation of pile head for load test and before erecting loading platform level of top of finished pile head shall be recorded using a precision levelling instrument. Again after load test is over and test load is removed, level of top of pile head shall be checked using the same levelling instrument to compare the difference in levels with level difference recorded through dial gauges.

c) A round plate of suitable thickness and always greater than the diameter of the pile that is to be tested, shall be placed over a fine layer of sand spread over the top of the pile.

d) A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main RSJs of the loaded platform. The jacks should preferably be connected and operated by one pump.

The Contractor shall submit certificates showing the correctness of the calibration of the pressure gauges and the jacks before use. All jacks shall be fitted with locking devices.

e) Another plate of suitable thickness shall be placed over the ram of the jack, which is later raised by operating the hydraulic pump so that the plate on the top of the ram butts against the bottom flange of the main RSJs of the platform.

f) Readings of settlement and rebound shall be recorded with the help of four dial gauges of 0.02 mm sensitivity and resting on diametrically opposite ends of the pile cap.

The dial gauges shall be fixed to a datum bar whose ends rest upon non-movable supports. The supports should be at least 5 x d away clear from the pile where "d" is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.

g) The test load shall be applied in equal increments of about 1/5 of the design load until the test load is reached.

h) Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done as under:

1. Test load to design load
2. Design load to 50% of the design load
3. 50% to 25% of the design load
4. 25% of the design loads to complete unloading

The rebound reading for each decrement shall be noted. The final rebounding shall be recorded 24 hours after the entire load is released. The safe carrying capacity of the pile shall be estimated in accordance with IS:2911.

B) Lateral Load Test on Piles

a) Two test piles shall be installed to the required depth and spacing as specified by the Employer. A hydraulic jack of adequate capacity shall be inserted in between them to apply the lateral load at the approximate cut-off level of the pile. Thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral deflections shall be measured at the thrust level by means of dial gauges fixed to immovable supports.

b) The loading shall be applied in one half tonne increments till the rate of deflection reduces to 0.02 mm/hour and a load deflection curve shall be plotted.

c) The loading shall be continued till the deflection of the pile top reaches the estimated value or the estimated safe load whichever is earlier.

d) When the full test load is applied it shall be kept on for 24 hours with observations made every hour and then released in 3 stages.

C) Plant and Equipment

All temporary work, plant equipment, kentledge for applying the load and all necessary instruments for measurement of loads, deflection, etc. shall be provided by the

Contractor. The equipment provided shall be capable of slowly applying and maintaining the required test loads to within an accuracy of 0.02 mm. The Contractor shall submit for approval of the Employer his detailed proposal for carrying out the load test.

D) Cost of Delay

The Contractor shall be deemed to have allowed in the construction programme the time required for testing of piles. No claim shall be entertained for any delay due to the testing programme.

E) Records

The Contractor shall submit to the Employer the following records of the tests:

a) Make and specification of jack, pressure gauge and dial gauges;

b) Calibration of pressure and dial gauges

c) Design load of pile, description of location and identification marks of pile

The readings for settlement and rebound shall be entered in the following form:

Time	Load	Dial	Settlement	Dial	Settlement	Mean Set	Remarks
1	2	3	4	5	6	7	8

F) Interpretation of Test Results

The pile shall be deemed to be acceptable under the following conditions:

Total settlement under the test load does not exceed 12 mm plus allowance for normal elastic deformation.

The increase in settlement between two consecutive increments of loading does not exceed 6 mm plus allowance for elastic deformation.

The elastic deformation is defined as shortening of the pile within the elastic limit of the materials forming the ingredients.

G) Standard of Acceptance

The piles shall be approved as satisfactory only when the work has been executed in accordance with the Specification and the standards stated below.

a) The head of the pile shall be within 75 mm of the specified position

b) The pile shall not be out of plumb by more than 2%

c) The toe of the pile shall be at the approved bearing level in each case

d) The total volume of concrete shall not be less than 95% and not more than 120% of the calculated volume. The calculated volume for this purpose shall be cross sectional area inside the casing multiplied by the length of the shaft

e) The concrete shall be of the design strength

Should a pile fail to meet the standard of approval specified above the Employer may take one of the following decisions:

a) Instruct the Contractor to carry out additional tests to ensure the soundness of pile.

b) Accept the work and allow the Contractor to make suitable alternation in the construction of piles/pile cap/and beams. The cost of modification in the pile/pile beams shall be borne by the Contractor.

c) Reject the pile/piles and instruct the Contractor to install additional piles at Contractor's expense.

The piles which fail to fulfil the standard of approval specified under Para (f) above shall be rejected and the Contractor, at his own cost, shall install additional piles as directed by the Employer.

H) Integrity Testing

Non-destructive integrity testing of bored piles, for 100% of piles, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low 'g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer etc. all complete. The test shall be conducted by the qualified and experienced specialists in this field. Employer's decision shall be final regarding approval of piles passing integrity test but of questionable workmanship.

4.3.2.13 Defective Piles

Piles, which have been declared defective by the Employer, shall either be removed or left in position as judged convenient by the Employer. If left in place, the cost of any modifications required in the pile/pile caps shall be borne by the Contractor in addition to the cost of construction of any replacement piles. If removed, all costs related to this shall be borne by the Contractor.

4.3.2.14 Finishing Pile Heads

The top of the piles shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the cap. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete and bonded into the old.

4.4 Site Grading

4.4.1 General

The Contractor shall first clear the area assigned for development from any obstructions or old structures and carry out a detailed topographic survey of the whole area. Formation level shall be such that there shall be no flooding of the site. It is proposed to provide the formation level of +53.00m MSL for the entire Site, upto the boundary wall of the terminal, stockyard, parking and road area & locations where buildings have to be constructed. While carrying out site grading, it is ensured that no existing natural drainage shall be blocked without providing required cross drainage structures or alternative drainage arrangement.

The demolition and disposal of the establishments like brick structures & hutments shall be in Contractor's scope. The tree cutting is included in contractor's scope and all clearances required for tree cutting shall be Contractor's responsibility. The access road will be relocated during the construction of terminal and shall be in the scope of Contractor.

The formation level of +53.00m MSL shall be achieved by carrying out cutting and filling of the existing ground levels inside the terminal area.

The Contractor shall satisfy himself as to the nature of the material to be excavated by examination of the Site and geo-technical investigation report available for the Project Site. The Contractor shall carry out any further investigations necessary to enable him to assess

and foresee the nature of the material and to decide on the most suitable type of equipment and method of excavation / cutting.

4.4.2 Material

4.4.2.1 Acceptable Fill Material

Fill material shall be granular, non-cohesive, naturally occurring and shall be free from organic and deleterious matter and shall have the following properties:

- Maximum particle size : 200mm
- Percentage maximum particle size : 10%
- Percentage passing 63 micron sieves : 10% maximum
- Liquid limit : 35% maximum
- Plasticity index : 6% maximum
- Chloride content (top 150mm only) : 3.3% maximum
- Sulphate content (top 150mm only) : 2.0% maximum

4.4.2.2 Unsuitable Material

Material, which has been deposited in reclamation areas and does not comply with the specification requirements for filling, shall be removed by the Contractor and replaced with suitable fill.

4.4.2.3 Testing

Contractor shall carry out testing in the reclamation fill to determine whether or not the materials placed conform to the requirement of the specification. The results shall be in a form and give such information as the Employer may direct.

4.4.2.4 Sampling

Unless directed otherwise by the Employer, sampling shall be carried out as follows:

i) Bag samples (large) (25kg)

Every day during the progress of filling, the Contractor shall take two bag samples of the materials placed in reclamation at locations directed by the Employer. Samples shall be taken at a maximum depth of 0.5m.

The Contractor shall carry out all of the following tests on each of the bag samples:

a) Sieve analysis (BS1377 Part 2 - Section 9.2)

b) Particle size distribution by hydrometer (BS1377 Part 2 - Section 9.5)

c) Specific gravity (BS1377 Part 2 - Section 8)

d) Bulk density (BS1377 Part 2 - Section 7)

4.4.2.5 Standards

Unless stated otherwise, testing of fill materials shall be carried out in accordance with BS812 and BS1377. The Relative Density of the reclamation fill shall be as defined in ASTM D4253 and the Contractor's attention is drawn to the requirement for both wet and dry methods of compaction to establish the maximum dry density. Alternative methods of assessing relative density, or density index as defined in Clause 4.6 of BS1377: Part 4: 1990, will be considered provided the Contractor undertakes comparative tests.

4.4.3 Compaction

4.4.3.1 General

During the reclamation process the Contractor shall place approved material within the reclamation area to achieve an in-situ density not less than 90% of the Maximum Dry Density (MDD) throughout the full thickness and lateral extent of the fill. The latter is defined in Clauses 3.5 & 3.6 of BS1377: Part 4: 1990 - Determination of the dry density/moisture content relationship using the 4.5kg rammer.

The uppermost zone of fill shall be placed and treated to ensure that the top 900mm of the fill has an in situ density not less than 95% MDD.

The in situ density shall be measured using the appropriate method described in Clause 2.1 of BS1377: Part 9: 1990 or similar approved.

4.4.3.2 Testing

The presence of pockets and layers of fine material and the degree of compaction achieved from placing fill shall be established by drilling boreholes through the fill. Boreholes shall be carried out to the required depth on an average of one in every 40,000m^2 or as directed by the Employer. In each borehole continuous undisturbed sampling shall be performed using a good quality sampler that will ensure a high recovery ratio. The Contractor shall propose a sampler and shall seek approval from the Employer prior to its use. Immediately upon extraction, each sample shall be subjected to a bulk density determination.

Around each borehole position three static cone penetrometer soundings shall be made, approximately 1.5m away from the borehole. The cone penetrometer soundings shall be made before the drilling of boreholes. The penetrometer equipment shall record data electronically and the data shall be made available to the Employer in approved format.

Each sample shall be subjected to minimum and maximum density determinations in accordance with ASTM D4254 and ASTM D4253 standard tests respectively and to Maximum Dry Density testing in accordance with Clause 3.5 and 3.6 of BS1377 : Part : 1990. When available quantities of fill material from individual samples are less than specified for the particular tests, mixing from immediately adjacent samples shall be permitted with the specific approval of the Employer. From the above tests the relative density, as defined in ASTM D4254, corresponding to 90% MDD shall be established for each sample.

At each borehole location the Contractor shall establish a correlation between cone resistance and relative density and shall prepare a relationship between cone resistance and depth for fill having a Relative Density corresponding to 90% MDD. Once this relationship has been agreed with the Employer the cone resistance depth profile shall be used to monitor the density of the whole fill.

The Contractor shall perform static cone penetrometer soundings on a square grid of 25m for the whole extent and depth of the reclamation that has been filled with dredged material. There shall be an agreed time interval between filling and sounding to allow for the equilibration of in situ water pressures. Where the soundings show cone resistance values less than the agreed profile the Contractor shall submit his proposals for improving the density of the fill. Repeat soundings shall be undertaken following any ground improvement.

The Contractor may wish to submit alternative methods for demonstrating that the Fill has achieved the specified density, these shall be submitted as an alternative and he shall submit a detailed method statement for evaluation.

In situ density testing shall be carried out on the upper 900mm of fill in reclamation area to determine the degree of compaction achieved. The rate of testing shall be one test per nominal 2,500m^2 and the Employer shall select any depth within the upper 900mm of Fill.

The in situ density of the upper 900mm shall be determined in accordance with the method described in BS1377: Part 9 - Section 2.1 or 2.2.

Laboratory tests to determine the moisture content/dry density relationship shall be performed on a representative sample of the fill material for each 5,000m^2 of fill placed in reclamation area. The location and depth of the test sample shall be determined on site by the Employer.

Additional testing shall be carried out on the top 300mm of fill in reclamation area as follows:

Test	Test Frequency (Not less than one test per)
Dry density	600 m^2
Moisture content/maximum dry density relationship	2000 m^2
Particle size distribution	2000 m^2
Atterberg limits	2000 m^2
Linear shrinkage	2000 m^2
CBR	2000 m^2
Sulphate content	2000 m^2
Chloride content	2000 m^2

4.4.4 Disposal of Surplus Excavated Material

Subject to provision of this specification all materials arising from site grading activity which are surplus or unsuitable for use in the Works shall become the property of the Contractor and shall be disposed of by him in an environment friendly manner either off the site up to a lead distance of 5 km as agreed by the client or if agreed by the Employer on the Site in an approved manner.

The Contractor shall propose two sites for disposal of unsuitable or surplus material, one of which shall be specified as having priority and which must be filled before the second is used, together with a separate location where hard debris, such as concrete, kerbing etc. shall be disposed of. The Contractor shall seek approval for all nominated sites from the concerned local authority before work commences.

4.4.5 Acceptance of Works

The Contractor shall undertake post-construction survey of the entire site so graded to confirm that the area has been developed to the required levels. The Employer shall not accept the Work unless the Contractor has carried out all the required tests with satisfactory

results. The entire area of the graded site shall be taken over completely by the Employer upon completion. The Employer shall not take over part of the area.

Interim payment for reclamation fill shall be based on quantities measured net using the calculated difference between the agreed ground levels from the surveys and upto date ground levels from interim surveys. Simpson's formula shall be used for computing fill volumes.

4.5 Internal Road Works

4.5.1 General

This section covers the specification of pavement including paver blocks for the construction of internal roads and parking area.

These specifications include the requirements in conformity with the dimensions shown in the drawings and with the lines and grades established by the Contractor at site subject to approval by the Employer.

The pavement shall be graded to allow the cargo handling equipment to operate at their optimum rates and to allow for storm water to the drainage system.

4.5.2 Granular Sub–Base

4.5.2.1 General

This specification covers the material which shall be laid in one or more layers as sub-base as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer. This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications.

4.5.2.2 Materials

The material to be used for the work shall be natural sand, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table-A.

While the gradings in Table-A are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding gradings for the coarse-graded materials for each of the three maximum particle sizes are given at Table-B.

Physical requirements

The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS :812 (Part III) . The water absorption value of the coarse aggregate shall be determined as per IS : 2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS : 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which be taken as being the density relating to a uniform air voids content of 5 percent.

TABLE-A: GRADING FOR CLOSE-GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve	Per cent by weight passing the IS sieve

DESIGNATION	GRADING I	GRADING II	GRADING III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	10-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

TABLE-B: GRADING FOR COARSE GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve	Per cent by weight passing the IS sieve		
DESIGNATION	**GRADING I**	**GRADING II**	**GRADING III**
75.0 mm	100	-	-
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	< 10	< 10	< 10
CBR Value (Minimum)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

4.5.2.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub–base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the “quality” of materials, as may be necessary.

4.5.2.4 Construction Operations

Preparation of subgrade

Immediately prior to the laying of sub-base, the subgrade shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-100 kN smooth wheeled roller.

Spreading and compacting

The sub-base material shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

When the sub-base material consists of combination of materials mentioned in Clause 4.5.2.2. mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS : 2720 (Part 2) and suitably by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS : 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used.

For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m2 or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS : 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

4.5.3 Cement Bound Material (CBM)

4.5.3.1 Material

The following materials to be used for Cement Bound Material (CBM) pavement construction shall be approved by the Employer based on laboratory tests or certifications of representative materials, which will be used in the actual construction.

Cement

Cement shall comply with BS EN 197-1. Cement test certificates from the manufacturer shall be presented to the Employer in accordance with BS EN 197-1.

Aggregate

(a) The material shall demonstrate freeze thaw resistance.

(b) Grading tests shall be performed in accordance with BS EN 933-1 at a frequency of one test per 100 tonnes of material.

(c) Aggregates shall be tested for sulphates and acidic matter capable of interfering with the hydration of cement at a frequency of one test per 100 tonnes of material, in accordance with BS EN 1744-1.

(d) The material shall be free from organic matter and shall have the following mechanical properties when tested in accordance with BS EN 1097:

  (i) Los Angeles Abrasion LA40

  (ii) Magnesium Sulphate Soundness MS25

  (iii) Water Absorption <6%

  (iv) Dry Density >2.3Mg/m³

  (v) Total Sulphate content shall not exceed 1% by mass of sulphate (SO3).

Water

Water shall be fresh from the local mains water supply. If not supplied from the local mains supply, water shall comply with BS EN 1008.

Admixtures

Any chemical admixture used in the mix shall comply with BS EN 934-2 and shall be submitted to the Employer for approval. Approval will be at the Employer's discretion.

4.5.3.2 Mix Design

The Contractor shall be responsible for the design and preparation of the mix so that it meets the strength and performance requirements for CBM C10 as shown in the following table and defined in BS EN 14227.

CBM REQUIREMENTS

Characteristic 28 Day Compressive Strength (N/mm²)	**Required Strength Class**	**Mean Axial Tensile Strength (N/mm²)**	**Minimum Long Term Flexural Tensile Strength (N/mm²)**
Cube Strength			

(H/D = 1)			
10.0	C10	1.55	1.5

The mix design shall follow guidance given in Cement-Bound Materials for Pavements published by the British Concrete Association and The Structural Design of Heavy Duty Pavements for Ports & Other Industries. The Contractor is required to design a consistent mix, with an appropriate water content, cement content and moisture content, which when compacted will meet the aforementioned strength requirements.

The Contractor is required to ensure that excessive early strengths are be avoided to minimise the possibility of macro-cracking of the CBM.

The mixture shall have water content not less than 95% of the Optimum Water Content (OWC) as determined on the mixture using BS EN 13286-4 vibrating hammer method.

The Contractor shall perform a minimum of three trial mix designs which meets the CBM required strengths, including strength after immersion, and submit the results to the Employer with a recommended final design mix for approval. The Contractor shall not modify any proportions or materials of the final mix design without prior approval of the Employer in writing.

4.5.3.3 Condition of the sub-base

Prior to placement of the CBM, the surface of the sub base shall be clean and free of foreign material, ponded water and frost prior to the placement of the pavement mixture.

The sub-base must be uniformly moist at the time of placement. If sprinkling of water is required to re-moisten certain areas, the method of sprinkling shall not be such that it forms mud or pools of freestanding water.

4.5.3.4 Compaction

All materials shall be placed with an approved high density double tamping bar paver capable of attaining the thickness, lines and grades indicated on the Drawings. The paver should be capable of placing material at a minimum of 90% insitu wet density.

The maximum laboratory wet density shall be determined in accordance with BS EN 13286-4 vibrating hammer method. In situ wet density shall be determined in accordance with BS 1377-9 Nuclear density gauge method.

The quantity of material in the paver shall not be allowed to approach empty between loads. Material shall be maintained above the auger shaft at all times during paving.

The paver shall proceed in a steady, continuous operation with minimal starts and stops, except to begin a new lane, and the Contractor shall coordinate delivery of loads accordingly. The maximum paver speed during laydown shall not exceed 3 metres per minute, unless the Contractor can demonstrate, to the satisfaction of the Employer, that higher speeds are obtainable without distress to the finished product.

The finished surface shall be free from any potholes, ruts, poorly constructed joints and loose material.

4.5.3.5 Rolling

If final density has not been achieved in the placement process, the Contractor shall determine the sequence and number of passes by vibratory and non-vibratory rolling to obtain the specified densities and tolerances.

Rollers shall only be operated in the vibratory mode while they are moving. Rubber-tire rollers may be used for final compaction. Additional rollers shall be used if specific density requirements are not obtained or if placing operations get ahead of the rolling operation.

The roller shall not operate within 600mm of the edge of a freshly placed lane until the adjacent lane is placed. If a dry joint is planned, the complete lane shall be rolled and dry joint procedures, shall be followed.

Areas inaccessible to large rollers shall be thoroughly compacted with walk-behind rollers or hand tampers.

Rolling shall continue until the required in-situ density requirements are met. Areas which fail to fully comply with the Employer's Requirements shall be removed and replaced at the Contractor's expense.

4.5.3.6 CBM joints

Longitudinal joints shall be constructed in straight lines which are continuous for the length of the pavement. On completion, the joints shall present the same appearance and texture, as the remainder of the surface and the accuracy of surface across the joints shall meet the criteria required. Longitudinal joints shall be subject to density testing procedures with the locations of the tests to be confirmed in agreement with the Employer.

Longitudinal joints shall not be situated in wheel-ways. The Contractor shall seek confirmation of wheel-ways from the Employer before commencement of the pavement work.

Any planned or unplanned construction joints that do not qualify as fresh joints shall be considered dry joints. On completion, the joints shall present the same appearance and texture, as the remainder of the surface and the accuracy of surface across the joints shall meet the surface tolerances specified within the Employer's Requirements.

Transverse joints are required at the end of the day's work or following any interruption in laying, which prevents continuity of rolling. The exposed vertical edge of transverse joints shall be cut back at least 300mm using a rock saw. They shall be formed at right angles to the longitudinal pavement. On completion, the joints shall present the same density and texture, as the remainder of the surface and the accuracy of surface across the joints shall meet the criteria specified. Transverse joints shall be subject to density testing procedures.

Prior to placing fresh mixture against a compacted cold vertical joint, the joint shall be rock sawn back to competent material. Wetting the sawn joint to prevent excess loss of moisture will be required before placement of the fresh lane of material.

For un-compacted edges or joints not vertical, the edge or joint shall be rock sawn vertically for the full depth. The exposed edges of the longitudinal joints shall be rock sawn back to firm material or 1.5 times the layer thickness, whichever is the greater. Edges shall be cut using a rock saw the full depth of the pavement. Any modification or substitution of the rock saw cutting procedure must be demonstrated to and accepted by Employer. In no case shall the cutting of the edge cause ravelling or tearing of the surface. The prepared edge shall be moistened prior to placement of fresh material against it.

Horizontal cold lift joints will not be permitted.

4.5.4 Concrete Block Paving

4.5.4.1 Materials

Concrete paving blocks shall comply with relevant IS codes and requirements given hereunder:

i) Cement

The cement used in the manufacture of precast concrete paving blocks shall be ordinary Portland cement complying with IS:269. The cement content of the compacted concrete shall be not less than 380 kg/m3

ii) Aggregates

The fine and coarse aggregate shall be natural aggregates complying with IS:383 and as given in Specification- Materials. The nominal maximum size of aggregate shall not exceed 20 mm.

iii) Water

Water shall be clean, free from deleterious matter and comply with IS:3025.

iv) Other Materials

Admixtures: Admixtures shall not be used without the approval of the Employer. The Contractor shall inform the Employer in writing of the admixtures to be used. Admixtures shall conform IS:9103. Pigments: Any pigments used shall comply with IS:3493.

v) Finishes

Natural Colour Blocks : A block described as 'natural colour' shall not container pigment.

Surface finishes: Surface finishes, including colour, shall be as directed or approved by the Employer. Pigmented blocks: When pigmented blocks are specified, samples shall be submitted to the Employer for approval.

vi) Dimension and Tolerances

Dimensions:

Nominal sizes and aspect ratios

Standard rectangular blocks shall be manufactured with a work size length of 200 mm and a work size width of 100 mm. The work size thickness shall be 60 and 80 mm.

vi) Wearing Surface Area

A chamfer round the wearing surface (no deeper than 7 mm) shall be permitted, and the work size and width of any chamber shall be declared by the manufacturers. The wearing surface area shall not be less than 70% of the plan area.

Tolerances:

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as given below:

- Length : $\pm$ 2mm
- Width : $\pm$ 2mm
- Thickness : $\pm$ 3mm

vii) Samples and Testing

a) Sampling

Sampling procedure shall be in accordance with IS: codes or equivalent

The Employer shall at all reasonable time, be permitted access to the place where the paving blocks are manufactured or stored, for the purpose of examining and sampling the materials and the finished paving blocks.

b) Compressive Strength

The compressive strength of paving blocks, sampled shall not be less than 50 N/mm^2 and the crushing strength of any individual block shall not be less than 40 N/mm^2.

c) Compliance with Specification

If concrete blocks are delivered to site from an approved manufacturer, the Contractor shall satisfy himself by testing that, at the time of delivery, the paving blocks comply with the requirements of this Specification and if requested by the Employer, shall forward a certificate to this effect, indicating the frequency of testing.

Should any of the test results, for either block manufactured on or delivered to Site, not comply with the requirements of this Specification, the consignment or batch as appropriate shall be rejected as not complying with the specifications.

4.5.4.2 Construction of Concrete Block Paving

Concrete block paving shall be laid to comply with IS:6509 and the requirements as given hereunder:

Subgrade

The preparation of the subgrade shall not commence until all subgrade drainage has been completed and side drains or channels are capable of removing water from the immediate vicinity of the formation.

The subgrade, sub-base and base shall be prepared so that:

i) The surface levels are within the tolerances given in Table C

ii) The longitudinal falls and cross falls are such that no depressions hold water. A minimum longitudinal fall of 1.25% and a minimum cross-fall of 2.5% shall generally be adopted.

iii) The surface is tight and dense enough to prevent laying course material being lost into it during construction and use.

iv) Provision is made to:

   a. drain water from the laying course in service (e.g. by installation of drainage when the laying course is on impermeable foundations)

   b. prevent migration and loss of laying course material into drainage (e.g, by use of a geotextile)

Trimming and regulation shall then be carried out to bring the formation to the correct level and grade within the tolerance stated in Table I and finally, the formation shall be re-rolled with a smooth wheeled roller having a load of not less than 2.5 t/m width of roll.

Sub-base

Materials for the sub-base shall comply with the requirements for granular sub-base given in Clause 4.5.2.2 of the Specification. The sub-base layer shall be laid on the prepared formation and compacted in accordance with Clause 4.5.2.4. The thickness of the sub-base shall be as per approved design.

Cement Bound Material (CBM) base

Where shown on the approved drawings or if specified by the Employer, the Contractor shall lay a CBM base for block paving as per Clause 4.5.3 of this specification.

Edge Restraints

Edge restraints shall be formed before compacting adjacent blocks.

Laying Course

The laying course shall consist of 2-10 mm naturally occurring coarse sand or crushed rock fines graded in accordance with IS:2386. The coarse sand or crushed rock fines shall not contain more than 3% by weight of clay, silt and fine dust. The moisture content of the laying course should be as uniform as possible and the material should be moist without being saturated.

The Contractor shall construct the laying course so that after compaction, it forms an approximately 30 mm thick layer below the paving blocks. The sand shall be stuck off to such a level that, when blocks have been vibrated, the upper face of the blocks shall be true to the finished level. Before the blocks are laid, the laying course shall not be subjected to any form of traffic including pedestrian traffic, before, after or during screeding.

Concrete Paving Blocks

Blocks shall be laid in herringbone bond, except where specifically instructed by the Employer. Blocks shall be placed firmly together without disturbance to the laying course and the order of placing the blocks shall ensure this.

At edges or obstructions such as gully grating or manholes, blocks shall generally be cut to fit. Cutting may be carried out with a hydraulic splitter, a hammer and bolster, or by sawing. Immediately adjacent to gullies and manholes the tolerance shall be +3 mm, -0 mm.

The laid blocks shall be compacted to the finished levels by a vibrating plate compactor which transmits an effective force not less than 75 kN/m^2 at a frequency of 75-100 Hz and has a plate area not less than 0.25 m^2. Sufficient passes shall be made to compact the laying course to produce an even surface.

Vibration shall not be carried out within 1 m of an unrestrained edge or laying face.

After initial vibration, sand or crushed rock fines shall be brushed into joints and further passes of the vibrating plate compactor made to fill the joints, more sand being spread over the surface if required.

The tolerances in Table-C apply on straight profiles. Equivalent tolerances shall apply on vertical curves. All profile devices such as pegs, pins, profile boards or guide wires shall be set to the true plan line with a maximum tolerance of +25 mm and to the true level with a maximum tolerance of +3 mm. Spacing of support pints for guide wires shall be less than 10 m.

1. Permissible tolerance on centre line of pavement construction relative to horizontal alignment: +10 mm.
2. Permissible tolerance on surface levels:

Table-C: Tolerances on Surface Level for Concrete Block Paving

Layer of Pavement	**Maximum permissible in deviation from design level (mm)**
Sub-grade	+ 20
Sub-base	+ 15
Road-base (Surface Course) - Overall	+ 6
- Flatness	10 under a 3 m straight edge 2 between adjacent blocks
Adjacent to gullies, surface drainage channels and outlets (see Note)	+6, -0

Note: The permissible deviations for the upper level of drainage inlets and channels should be +0, -0 mm to ensure positive drainage.

4.5.4.3 Kerbs and Gutters

Kerbs

This work comprises the construction of concrete kerbs in situ, and installation of precast concrete kerbs on foundation concrete laid on prepared subgrade, sub-base, base-course, asphalt or concrete surface. Kerbs shall be provided at the locations to the lines, grades, and typical sections as per approved Drawings or established by the Employer.

Materials

Cement shall be ordinary Portland cement to IS:269.

Aggregates shall conform to the requirements of Specification - Materials. All aggregate shall be of a size appropriate to the sections and method of manufacture of the kerbs. The coarse aggregate to be used, when tested in accordance with IS:2386 shall not exceed the following limits:

- Aggregate crushing value 30%
- Flakiness Index 35%

The preparation and placing of concrete shall conform to the requirements of the Specification, Section 2, Plain and Reinforced Concrete. Reinforcement, where used, shall comply with the Specification Section 2, Plain and Reinforced Concrete.

Equipment

Equipment shall be of the number and type outlined in the Contractor's Programme of Work as approved by the Employer.

In-situ Kerbs

Concrete Class

In situ kerbs shall be constructed of concrete OPC 25/20. Expansion, contraction and construction joints for kerbs

Joints shall be constructed at the intervals and places as approved by the Employer. All joints shall be of the type and materials and conform to the approved dimensions of the kerb.

When constructed in connection with or abutting concrete pavement, the method of constructing the joints in kerbs shall conform to the requirements for joints in the pavement.

When constructed separately from concrete pavement, or in connection with flexible base or surface courses, contraction joints in kerbs may be constructed by sawing through the kerb to a depth of not less than 32 mm below the surface of the gutter. Alternatively contraction joints may be formed by inserting an approved removable metal template in the fresh concrete, or by other methods approved by the Employer.

Sealing of the joints will not be required unless the kerb and is constructed in connection with or abutting concrete pavement.

Precast Kerbs

Precast concrete kerbs shall comply with IS:5758 and be manufactured by hydraulic pressing. Form for precast kerb shall be constructed so that the kerb sections will conform to the approved shape and dimensions.

4.5.4.4 Construction Requirements

Subgrade

Soil below subgrade level to a depth of 200 mm in cut shall be scarified, broken up, adjusted to optimum moisture content and re-compacted to the required density. If Quality Control tests show the required compaction cannot be achieved, the layer shall be replaced with suitable excavated material.

Subgrade in cut shall have a minimum CBR value as per requirement of relevant IS Codes.

When the subgrade is formed on ramps, it shall be to the full width of the top of the ramps. Material placed in the top 300 mm of ramps, shall exclude particle sizes greater than 75 mm and shall have a minimum subgrade CBR value as per requirement of relevant IS Codes.

The width to be excavated shall be 300 mm each side of the outside edges of the kerb or gutter. The subgrade shall be of uniform density as approved by the Employer. Rock, shale, or soft and yielding material shall be excavated 15 mm below subgrade elevation and replaced with suitable backfill material. The backfill material shall be compacted to meet the compaction requirements specified in Clause 4.4.3 of this specification. All subgrade shall be rolled or compacted to provide a smooth surface and shall be approved by the Employer before placing concrete.

Concrete

Concrete kerb foundation and backing concrete shall be OPC 15/20. The composition, consistency, proportioning, batching, mixing and curing of concrete shall conform to the requirements of Section 2.

The area to be covered with the kerb shall, immediately after finishing, be cleaned of all laitance and roughened. The concrete shall be placed and compacted and then shaped with a steel tool conforming to the section. The Concrete shall be compacted with an approved internal vibrator or by hand spudding and tamping. The surface shall be shaped by use of a steel tool to produce the section. The edges shall be rounded by the use of wood moulding or by the use of an edger to form the required radius.

Reinforcement

Reinforcement, if required shall be held in the position by clips, bar chairs, or other approved devices.

Precast kerbs

Precast kerb sections shall not be moved (except as required for the removal of forms) or placed until the concrete has attained 75% of the design 28 day strength.

Precast kerb sections shall be set in a sand-cement grout on the concrete kerb foundation. They shall be butted up close together without mortared joints unless otherwise mentioned or instructed by the Employer.

Grouted joints, where indicated, shall consist of the one part Portland cement and three parts of fine aggregate, and one-fifth part of hydrated lime with sufficient water to produce a plastic mix as approved by the Employer. Grouted joints shall be cured by an approved method for a minimum period of four days.

Where kerbs are laid with concrete pavement, joints shall be provided in the kerb, foundation and backing in the same locations as in the pavement, and constructed and sealed to similar details using the same materials.

For curves of 12 m radius or less, precast kerbs or appropriate radius or length shall be used. Kerb units shall not deviate from line and level by more than 3 mm in 3 m. Standard precast concrete quadrant units shall be used where appropriate.

Finishes

a) In situ kerbs : surface shall be uniform and smooth finish

b) Precast kerb: surface shall be finished to a true and even. Surfaces concealed in the forms will require no finishing. All voids and honeycombed areas shall be repaired with a sand-cement grout.

Curing

Kerbs shall be cured in accordance with the provisions for Section 3.2, Plain and reinforced concrete Clause 4.2.14.

Backfill

The area adjacent to kerbs shall be backfilled with approved material to the top edges of the kerbs. The backfill shall be placed and compacted to a density equal to or greater than the adjacent undisturbed natural ground.

4.5.5 Removal of Surplus Earth

Surplus earth and soil from excavation shall be removed from construction area to the area demarcated by the Employer.

4.5.6 Brick Pitching

4.5.6.1 Excavation

Trench shall be excavated/dressed true to line, section and grade as per approved drawings prior to starting the pitching work.

4.5.6.2 Material

Bricks shall be locally available best quality bricks as per Specification - Brick Masonry Work.

Cement, sand and water used shall be as per Specification - Material.

The concrete mix used for bedding shall be as per Specification - Plain and Reinforced Concrete.

4.5.6.3 Workmanship

The work of pitching shall be done after the bottom concrete has been laid and sides properly trimmed to the required grade and thoroughly compacted.

Brick pitching shall be done in 1:4 cement mortar using first class locally available bricks. Bricks shall be laid in herringbone pattern with their length at 45° to the length of the ditch as shown in drawings.

Mortar joints shall never exceed 6mm in thickness and all bricks shall be laid with vertical joints quite full of mortar.

Bricks shall be soaked for a period of at least 12 hours immediately before use and no broken or damaged brick shall be used in any part of the work except such as will be required to close any line of bricks. The face of pitching shall be made even and smooth.

The brickwork shall be raked and flush pointed with cement mortar 1:3 as specified.

4.5.7 Traffic Markings

4.5.7.1 General

This work shall consist of the painting of white or yellow lines, chevron striping, arrows and lettering on road, pavements and painting on kerbs.

4.5.7.2 Material

Thermoplastic material for road markings shall comply with specification for road and bridge works published by IRC. Road markings shall be white or they shall be yellow complying with IRC specifications and as directed by the Employer.

Chlorinated rubber paint for painting kerbs shall be plasticised and drying shall be by solvent evaporation alone. It shall have the properties given in Table II given below.

Epoxy resin adhesive shall comply with AASHTO M237

Table II: Paint for Kerbs

Property	**Allowable Limits**
Relative density	1.48 minimum
Viscosity at 21^0C	65 to 70 KU
Drying Time	Approx. 10 –15 min
Coverage	3 m^2 per litre maximum
Brightness	80 minimum
Flexibility	Passes around 12 mm diameter mandrel
Chlorinated rubber content	9.0%

4.5.7.3 Quality Assurance

The quality and workmanship of the completed marking installation shall conform to the best modern practice.

The complete marking installation shall be warranted to the Employer from the date of issuance of certificate of final completion against peeling, chipping, flaking, delaminating and shoving for a period of one year or until the markings are normally worn away by traffic.

The Contractor shall submit his programme schedule, catalogues, manufacturer's specifications and test data of products proposed to use in this work to the Employer.

4.5.7.4 Construction Requirements

General

Traffic shall be kept off markings until the installation has fully cured.

Road Marking

Spraying equipment shall consist of a motor powered self-propelled machine with compressor. A minimum line width of 100 mm shall be sprayed in one pass. The bead gun shall be synchronized to spray glass spheres immediately onto the hot thermoplastic. An

automatic skip mechanism shall be fitted to produce broken and dotted lines without pre-measurement.

If hand methods are used the Contractor shall provide stencils, specialised labour and anything necessary so that the results obtained match in quality and finish the mechanically sprayed work to the approval of the Employer.

Lines, chevron striping, arrows and lettering shall be provided to the size and in the location as per approved Drawings and in accordance with the Indian Road Congress Standards. Kerbs shall be painted alternately black and yellow covering the entire exposed surface. Changes in colours shall be made at joints between kerbs.

The surface to be painted shall be clean and dry. Pre-marking for painting shall be done manually on straight lines and curves using a 100 m long string. On straight the pre-marking shall consist of 1 dot mark every 3 m, and on curves every 1 m. The pre-marking dot shall be a circle of 40 mm diameter cut into an equal parts by a gap of 100 mm. Longitudinal changes in lines types shall be within 300 mm of the location as per the approved Drawings.

Paint shall be applied 1.5 mm thick for broken, dotted and continuous lines, stripping, pedestrian crossings, stop lines, special letters, arrows and symbols shall be 3 mm thick. In addition to the ballotini premixed in the material, a further quantity shall be sprayed onto the hot spray-plastic markings at a rate of application of 400 – 500 g/m2.

Road Sign

Road sign to be supplied and fixed in accordance with the specification for road and bridge works published by Indian Road Congress or as directed by the Employer. The entire work of the installation and materials shall meet the approval of the Employer.

4.6 Storm Water Drainage

4.6.1 General

The intent is to drain the storm water of entire terminal area without any undue pooling and finally water to be let into the river.

4.6.2 Scope

The schematic layout of drainage system is shown in **Drawing I-525/KGT/1017**.

Storm drainage consists of furnishing transportation, labour, equipment and materials to construct storm drainage system in accordance with Contractor own Design and Drawings complying Indian standards. The work includes construction and installation of the following:

a) Reinforced concrete pipe for storm water conveyance.

b) Open Concrete drain as well as box drains for collection and conveyance of storm water.

c) Storm drain outlets into river including flap gates and related features.

d) Sewage Collection & Transfer system

4.6.3 Materials

4.6.3.1 Precast Concrete Pipe and Fittings

All reinforced concrete pipes shall be class NP3 conforming to IS: 458. RCC pipe shall be of NP4 type shall be used below road.

4.6.3.2 Flap Gate

The drainage gate shall be designed to allow free outflow and prevent backflow for maximum seating heads up to 7.6 meters (25ft). The gate shall be provided with adjustable, double pivoted hinge links so designed to permit complete seating, full opening, and with stops or other arrangements to prevent cover from rotating sufficiently to become wedged in the open position. Pivot lugs mounted to frame shall be adjustable to allow adjustment of hinge links without having to remove cover from gate. The hinge links shall be bronze-bushed, structural steel (or high strength ductile iron, cast manganese bronze or wrought stainless steel). All assembly hardware shall be stainless steel.

The frame shall be cast iron, cast in one piece, with reinforcing ribs and a cast on lining eye shall be provided for manual operation. The frame shall have a machined seating surface inclined from vertical at minimum of 2.5 degrees to assure positive closure.

All cast iron shall be painted with manufacturer's standard shop coat paint (or special paint). Structural steel hinge links shall be galvanized. All bronze and stainless steel parts do not require further finish.

4.6.4 Execution

4.6.4.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches. The details of catch pit, drainage channel are shown in drawings.

4.6.4.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement. Pressure Testing: The length of pipe shall be tested as per Indian Standard.

4.6.4.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.6.4.4 Storm Drain Cleaning

Prior to final acceptance and final catch basin-to-catch basin inspection of the storm drain system by Employer, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the storm drain at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.

Upon Engineer's final catch basin-to-catch basin inspection of the storm drain system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

4.6.4.5 Tolerances

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

4.6.5 Inspection

Prior to final approval of any pipe installation, a thorough inspection shall be made of entire installation. Any indication of defects in material or workmanship, or obstruction to flow in the pipe system, shall be further investigated and corrected as necessary by the Contractor at no additional cost to the Employer.

4.6.6 Construction of Catch Basins and Trench Drains

4.6.6.1 Excavation and Backfill

Excavation and backfill as required accomplishing the construction. Backfill shall be as specified for the adjoining pipe trench. Install catch basins and trench drains at the locations based on IS code and as specified herein. Construct forms to the dimensions and elevations required for cast-in-place units. Forms shall be tight and well braced.

4.6.6.2 Concrete Work

- Cast-In-Place Concrete

Prior to placing formwork compact existing insitu soil and provide a layer of compacted bedding material.

Prior to placing the concrete, remove all water and debris from the forms. Place the concrete and screed the top surface of exposed slabs and walls. When the initial water has been absorbed, float the surfaces with a wood float and lightly trowel with a steel trowel to a smooth finish free from marks or irregularities. Finish exposed edges with a steel-edging tool. Remove forms and patch any defects in the concrete as required.

Cure concrete by preventing the loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply the curing compound immediately after removal of forms or finishing of the slabs. Protect concrete from damage during the 7-day curing period.

Precast Units

Prior to placing precast units compact existing in-situ soil and provide a layer of compacted bedding material.

4.6.6.3 Extensions

Extensions to be installed as per requirement. Lay risers in mortar with sides plumb and tops to grade. Joints shall be sealed with mortar, with interior and exterior trowelled smooth. Prevent mortar from drying out and cure by applying a curing compound. Extensions shall be watertight.

4.6.6.4 Installation of Frames and Grates

Set frames and grates at elevations indicated or as determined in the field and in conformance with the design and Drawings. Frames may be cast in, or shall be set in mortar.

4.6.6.5 Cleaning

Upon completion, clean each structure of all silt, debris, and foreign matter.

4.6.6.6 Final Grades for Field Inlets

The final finish grades of top of grate on all storm water inlets and trench drains shall be adjusted to receive surface flows without pooling. No inlets will be acceptable if it protrudes above the finish-paving surface.

4.6.7 Installation of Flap Gate

Install flap gates at locations as per manufacturer's recommendations.

4.6.8 Rain Water Harvesting System

Rain water harvesting system shall be provided for all the buildings in the terminal.
Design shall be carried out as per guidelines of Rain water Harvesting Manual of CPWD.

4.7 Earthwork

4.7.1 General

This section of the specifications includes requirements for accomplishing all earthworks including filling, anti-termite treatment, riprap and yard grading for this Contract.

4.7.2 Nature of the Ground

The Contractor shall judge for himself the nature of the ground and shall be fully responsible for ascertaining all necessary information concerning permanent water table period of rainfall, flooding of the site and all matters affecting the excavation & foundation work.

4.7.3 Earthwork Method

The Contractor shall not undertake any earthwork; including the operation of any borrow area or quarry, without having obtained the EMPLOYER'S prior approval to the methods which he proposes to employ. He shall not thereafter modify such methods without the consent of the Employer.

4.7.4 Correct Widths and Depths of Excavations

In the event of excavation being made larger than the sizes shown on the drawings, the Contractor shall fill in the excavated void to the correct profile with mass concrete as described under specification for 'Plain and Reinforced Concrete' or other approved compacted material at his own expense.

4.7.5 Method of Excavation

Excavation may be carried out by machine or any other method approved by the Employer. In soil, excavations shall be taken to within 150 mm of the formation or foundation level and all subsequent excavation in any section must be carried out by hand not more than 24 hours before the commencement of construction in that section unless agreed otherwise by the Employer.

As soon as possible after inspection by the Employer, the bottom level of the excavation shall be sealed with blinding if specified and the required construction shall commence. No excavation for foundations shall be filled in or covered with concrete until the Contractor has notified the Employer that it is ready for inspection and has received sanction to proceed with the works. The Contractor shall give a minimum of 24 hours' notice of any inspection.

4.7.6 Shoring Excavations

The contractor shall be responsible for the design of shoring for proper retaining of sides of trenches, pits etc. with due consideration to the traffic, superimposed loads etc. Shoring shall be of sufficient strength to resist the pressure and ensure safety from slips and to prevent damage to work and property and injury to persons. Should any slips, falls or settlement nevertheless occur they shall be made good by the Contractor at his own expense with selected fill or with mass concrete as may be directed by the Employer.

In removing shoring from the sides of excavations, care shall be taken to avoid loads on to any concrete until it has hardened sufficiently to carry such loads. Timber or other materials

used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left in by the Employer.

The Contractor shall submit to the Employer for inspection calculations and working drawings for the proposed scheme of strutting and retaining the sides of the excavations not later than four weeks before commencing any excavations and shall not proceed with the appropriate section of the works until receipt of the EMPLOYER'S written consent.

The receipt of such consent shall not relieve the Contractor of any of his duties and responsibilities under the Contract.

4.7.7 Staking

The earthwork operations comprise the establishment of layout plans and staking for the installations at the start of the work, in conformity with the construction plans. The general staking plan shall be submitted by the Contractor to the Employer for his approval before the start of the work. All of the topographical references as well as any other supplementary references which are deemed necessary for proper execution of the work shall be marked out on the drawings and established on the ground by visible and stable landmarks.

Additional supplementary staking shall be established as may be necessary for horizontal and vertical reference points subject to approval by the Employer. The Employer reserves the right to make changes in grade to suit developed conditions.

4.7.8 Filling & Backfilling Generally

During compaction the backfill as specified in Clauses 4.7.8.1 & 4.7.8.2 below shall have uniform moisture content within 2% of the optimum for the compaction plant employed or as may be directed by the Employer after tests. Where necessary the Contractor shall adjust the moisture content of the backfill material either by drying out or by adding water. After such drying out or adding of water, the backfill shall be thoroughly mixed until the moisture content is uniform. Should the material being placed as filling or as backfilling while acceptable at the time of selection, become unacceptable to the Employer due to exposure to weather conditions or due to flooding or have become puddled, soft or segregated during the process of the works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

When placing the filling or backfilling the Contractor shall make due allowance for any settlement that may occur before the end of the Period of Maintenance remove any excess material or make up any deficiency of backfilling to the specified levels.

4.7.8.1 Backfilling with Excavated Material

Foundation trenches, column bases and the like may be backfilled with selected excavated material if approved by the Employer, these being well rammed and consolidated by hand or compacted by an approved vibratory 5 ton roller or other approved vibratory equipment in layers not exceeding 150 mm thick, to achieve a dry density not less than the maximum dry density obtained as per IS 2720 (Part 8).

4.7.8.2 Selected Granular Fill

Where directed by the Employer or where the drawings indicate the use of selected granular fill, this shall comprise well graded non-plastic granular material, placed in layers not exceeding 150 mm. Each layer being well compacted by an approved vibratory 5 ton roller or other approved vibratory equipment before the next layer is placed. The density after compaction shall not be less than the maximum dry density obtained as per IS 2720 (Part 8).

Selected granular fill shall be obtained from an approved source and shall comply with Clause 4.7.8.3 below.

4.7.8.3 Suitable Material

i) It shall be the responsibility of the Contractor to locate suitable material and carry out such tests as the Employer may require demonstrating the suitability of the fill to be supplied.

ii) The fill shall have minimum stone 75 mm, liquid limit not exceeding 25% and plasticity index not exceeding 6. Total water soluble salts shall not exceed 3%.

iii) Material shall have a CBR not less than 30% at 95% maximum dry density.

4.7.8.4 Underwater Placement of Fill Material

The method of operation for underwater placement of material obtained from borrow locations, duly approved by the Employer is subject to the approval by the Employer. The methods of fill placement shall be designed so as not to result in any detrimental pollution of the waterway.

4.7.8.5 Compaction

Compaction methods and layers shall be submitted to the Employer for approval.

Compactions shall be performed with approved vibratory compaction equipment well suited to the soil being compacted. Material shall be moistured or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction. Finished slope fill shall be stable before placing slope protection.

4.7.8.6 Tolerance

After installation and compaction of fill and backfills the levelling tolerances will be as follows:

- 2 cm from the levels indicated on the drawings
- ½% on any plane

On slope or vertical tolerance of $\pm$10 cm at any point will be permitted before placing slope protection. If these tolerances are not achieved the works will be corrected to the EMPLOYER'S approval at the Contractor's expenses.

4.7.9 Trimming of Slopes

The slopes of cuttings & embankments shall be trimmed by hand or by approved mechanical means to uniform batters as directed by the Employer.

Any rock or boulder appearing in the face of a cutting shall be trimmed back to within the tolerance specified above and in addition any such rock or boulder which in the opinion of the Employer is unstable shall be completely removed and the resulting void filled with compacted material with the approval of the Employer.

4.7.10 Draining of Excavation

All excavations shall be kept free of water at all times and the Contractor shall provide efficient appliances and drains for dealing with water to the approval of the Employer.

Particular care shall be taken to keep dry, rock and other surfaces against or upon which concrete may be deposited and proper precautions shall be taken to prevent the leaching out of cement or otherwise damaging unset concrete.

4.7.11 Existing Levels

Before work commences at the site the Contractor shall agree to the existing ground levels with the Employer.

4.7.12 Disposal of Surplus Excavated Material

Subject to provision of this specification all materials arising from site clearance which are surplus or unsuitable for use in the Works shall become the property of the Contractor and shall be disposed of by him either off the site or to an approved tip off of if agreed by the Employer on the Site in an approved manner.

The Contractor shall propose two sites for disposal of unsuitable or surplus material, one of which shall be specified as having priority and which must be filled before the second is used, together with a separate location where hard debris, such as concrete, kerbing etc. shall be disposed of. The Contractor shall seek approval for all nominated sites from the concerned local Employer before work commences.

4.7.13 Trench Excavation

The Contractor shall execute to the required alignment and depth separate trenches unless otherwise indicated, for each utility run. The trench shall be sufficiently wide for the proper laying of the utility and shall be excavated to a depth that provides necessary cover.

The bottom of all trenches may be over excavated to a minimum of 15 cm to allow for bedding material. Condition in the trench shall be such that connections can be accomplished without getting mud, silt, gravel or other materials to the joint. The trench shall be adequately dewatered before laying bedding.

The bottom of utility trenches shall be graded to secure the required slope and tamped as necessary to provide a firm bed. Backfilling in the trenches shall be well compacted to the approval of the Employer.

When trench excavation is required across existing surfaced roads as well used tracks, the Contractor shall provide and maintain a suitable graded diversion complete with adequate signs, all to the approval of the Employer. Such excavations shall be backfilled in accordance with Clause 4.7.8.0 & 4.7.8.1. Where road has a sealed surface this shall be replaced after the backfill has been suitably consolidated to the approval of the Employer and approved.

4.7.14 Protection of Services

The Contractor shall ascertain for himself the location of all permanent main services, and shall maintain and protect these where affected by the works and shall in no way interfere with these permanent services without receiving the written permission of the Employer.

4.7.15 Trenches not to be Left Open

Trench excavations shall be carried out expeditiously and subject to any specified requirements of the Contract, the backfilling and surface reinstatement of the trench shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and joined.

4.7.16 Polythene Sheeting

Polythene sheeting where necessary shall be of 1000 gauge and of approved manufacture supplied in rolls and laid by rolling over the prepared base at the levels and in the areas shown on the drawings. Where a joint is necessary at the side or at the end of a sheet, this shall be double welt folded joint made by placing the edges together & folding over twice. The joint shall be prevented from opening prior to concreting by blocks placed at intervals on top of the joints.

The Contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the approval of the Employer.

4.7.17 Anti-Termite Treatment

The treatment shall be carried out by an approved specialist sub-contractor. The chemicals used shall conform to IS:8944.

4.7.17.1 Treatment to Soil under Slabs at Plinth Level & Ground Floor

After earth filling and before the dry rubble or core packing, the centre surface of the filled earth will be treated with a chemical emulsion recommended by the specialist sub-contractor at the rate specified by the manufacturer. Light rodding shall be done to facilitate spraying and absorption.

4.7.17.2 Treatment to Junction of Wall & Floors

Rodding to be carried out along the junction of plinth beams and earth filling at 15 cm intervals and recommended chemical emulsion sprayed at the rate of 2 litres per linear meter so as to mix intimately with the soil.

Above clauses 4.7.17.1 and 4.7.17.2 shall be carried out simultaneously to establish the chemical barrier.

4.7.17.3 Treatment to Soil along the External Wall Perimeter

After levelling and before flagging or plinth protection is laid, soil along the external wall perimeter of the building upto a depth of 30 cm shall be treated at the rate of 4.5 litres emulsion per linear meter of plinth walls. If necessary rodding at 30 cm intervals shall be carried out to facilitate spraying and absorption.

Treatment of Critical Areas

Soils under piers, utility pipe openings, floor drains and electrical conduit entry joints shall be thoroughly flooded with the chemical emulsion at an approximate rate of 25 to 30 litres per square meter. If drainage pipes are laid along the walls and the chemical barrier laid as per paragraph 4.7.17.2 is disturbed/broken, additional treatment to such areas will be necessary.

4.7.17.4 Guarantee for 5 Years

The specialist agency shall provide a guarantee that buildings shall be free from termite infestation for a period of 5 years from the expiry of defects liability period. The form of guarantee to be provided is given at the end of this section in Appendix C.

4.7.17.5 Precautions

Precautions shall be taken not to disturb the treated areas by levelling, digging or earth filling, as this will break the chemical barrier. In case such situation arises, the area is to be treated again to restore the chemical barrier

4.8 Brick Masonry Works

4.8.1 General

This specification establishes the materials, dressing, laying, joining, curing, workmanship etc. for brick masonry works. Brick masonry shall also comply with all the requirements of IS:2212.

4.8.2 Materials

Refer specifications under 'Materials'.

4.8.2.1 Cement Mortar

Cement mortar shall meet the requirements of IS:2250 and shall be prepared by mixing cement and sand by volume. Proportion of cement and sand shall be 1:6 (1 part of cement and 6 parts of sand), or as directed by the Employer for brick masonry of one brick thickness or more, while 1:4 cement mortar (1 part of cement and 4 parts of sand) shall be used for brick masonry of half brick thickness. The sand being used for mortar shall be sieved. The mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within initial setting time of cement after water is added to the dry mixture. Mortar unused for more than initial setting time of cement, shall be rejected and removed from the site of work.

4.8.2.2 Proportioning

The unit of measurement for cement shall be a bag of cement weighing 50 kg and this shall be taken as 0.035 cubic metre. Sand shall be measured in boxes of suitable size on the basis of its dry volume. In case of damp sand, its quantity shall be increased suitably to allow for bulkage.

4.8.2.3 Mixing

The mixing of mortar shall be done in a mechanical mixer operated by power.

Mixing in Mechanical Mixer

Cement and sand in specified proportions, by volume, shall be thoroughly mixed dry in a mixer. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than that which shall bring the mortar to the consistency of stiff paste. Wet mix from the mixer shall be unloaded on water-tight masonry platform, made adjacent to the mixer. Platform shall be at least 150 mm above the levelled ground to avoid contact of surrounding earth with the mix. Size of the platform shall be such that it shall extend at least 300mm all-round the loaded wet mix area. Wet mix, so prepared, shall be utilised within initial setting time (thirty (30) minutes for ordinary Portland cement conforming to IS:269 after addition of water. Mixer shall be cleaned with water each time before suspending the work.

4.8.3 Construction Procedure

4.8.3.1 Soaking of Bricks

Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of bricks as well as to remove dirt, dust and sand. Proper soaking of bricks shall prevent the suction of water from the wet mortar, as otherwise mortar will dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use as they are likely to slip on mortar bed and there will be difficulty in achieving the plumbness of wall as well as proper adhesion of bricks to mortar. The period of soaking

shall be determined at site by a field test by immersing the bricks in water for different periods and then breaking the bricks to find the extent of water penetration. The least period that corresponds to complete soaking, will be the one, to be allowed for in the construction work.

The soaked bricks shall be removed from the tank, sufficient early, so that at the time of laying, they are skin dry. The soaked bricks shall be stacked over a clean place, wooden planks or masonry platforms to avoid earth, dirt being smeared on them.

4.8.3.2 Laying

Brick Work (one or more brick thickness)

Brick work (one or more brick thickness) shall be laid in English Bond unless otherwise specified. Half or cut bricks shall not be used except when needed to complete the bond. In no case the defective bricks shall be used.

A layer of average thickness of 10mm of cement mortar shall be spread on full width over a suitable length of lower course or the concrete surface. In order to check and achieve uniformity in masonry, the thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure equal to four times the actual thickness of the brick plus 30mm. Each brick with frog upward, shall be properly bedded and set in position by gently tapping will) handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. After completion of the course, all vertical joint shall be filled from top with mortar.

All brick courses shall be taken up truly plumb; if battered, the batter is to be truly maintained. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. The level and verticality of work in walls shall be checked up at every 1 m interval.

The masonry walls of structures shall be carried up progressively, leaving no pan 1 me lower than the other. If this cannot be adhered to, the brick work shall be raked back according to bond (and not left toothed) at an angle not more than 45 degrees but raking back shall not start within 60 cm of a corner. In all cases returns, buttresses, counter forts, pillars etc. shall be built up carefully course by course, and properly bonded with the main walls. The brick work shall not be raised more than fourteen (14) courses per day.

At the junction of any two walls, the bricks shall at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work.

The courses at the top of plinth and sills, at the top of the wall just below the soffit of the roof slab or roof beam and at the top of the parapet, shall be laid with bricks on edge. Brick on edge course shall be so arranged as to tightly fit under the soffit of the roof beam or roof slab, restricting the mortar layer thickness upto 12mm, however, any gap between the finished brick work and soffit of roof slab /beam shall be suitably sealed with the mortar.

Brick Work (half brick thickness)

For brick walls of half brick thickness, all courses shall be laid with stretchers. Wall shall be reinforced with 2 nos. - 6mm diameter mild steel reinforcement bars, placed at every fourth course. The reinforcement bars, shall be straightened and thoroughly cleaned. Half the mortar thickness for the bedding joint shall be laid first and mild steel reinforcement, one on each face of the wall, shall be embedded, keeping a side cover of 12mm mortar. Subsequently, the other half of the mortar thickness shall be laid over the reinforcement covering it fully.

The reinforcement bars shall be carried at least 150mm into the adjoining walls or RCC columns. In case the adjoining wall being of half brick thickness, the length of bars shall be

achieved by bending the bars in plan. During casting of reinforced concrete columns, 6mm dia. M.S. reinforcing bar shall be placed at every fourth course of brick masonry. At the junction of two walls, the brick shall, at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work. The brick masonry work shall not be raised more than 14 courses per day.

Brick course under the soffit of beam or slab, shall be laid by restricting the mortar thickness to 12mm. However, any gap between the finished brickwork and soffit of slab/beam, shall be suitably sealed with the mortar.

Cavity Walls

Brick work in cavity walls shall be included with general brickwork. It shall consist of one wall of one or more brick thickness while the other wall shall be of half brick thickness at a clear gap of 50mm. The brick work on either side of cavity shall conform to the specifications already stated under sub section 8.3.2.1 and 8.3.2.2. At the base of the cavity wall, the walls shall be solidly constructed upto 300mm above the ground level. The cavity wall shall be terminated 300mm below the soffit of roof slab/beam and the courses over this shall be continued in solid brickwork.

Cavity should be continuous and free from obstructions. Mortar droppings shall be prevented from falling down the cavity by the use of laths or by hayhands which shall be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall-ties, shall be removed daily and temporary openings shall be provided to permit the daily removal of mortar droppings from the bottom of the cavity.

The outer and inner leaves shall be tied by means of wall ties. Ties shall be of mild steel round bars of 8mm dia. 200 long with hooks at both the ends. These shall be placed not more than 750mm c/c horizontally and not more than 300mm vertically, and staggered. Additional ties shall be provided near the openings. There shall at least, be 5 ties per square metre of surface area of the wall. Ties shall be given a bituminous coat before placement, to protect them from corrosion.

In order to keep the cavity dry, air slots shall be provided in the cavity walls at bottom as well as top to the extent of 50 sq.cm area of vents to every 2.0 sq. metre area of the wall.

Circular Brick Work

The detailed specification for brick work covered under sub section 8.3.2.1 and 8.3.2.2 shall apply, in so far as these are applicable. Bricks forming skew backs, shall be dressed or cut so as to give proper radial bearing. Defects in dressing of bricks shall not be covered up by extravagant use of mortar, nor shall the use of chips etc, be permitted.

The circular brick work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flushed with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall be between 5mm and 15mm.

4.8.4 Jointing

Joints shall be restricted to a width of 10mm with brickwork of any classification. All bed joints shall be normal to the pressure upon them i.e. horizontal in vertical walls, radial in circular brick masonry and at right angles to the face in the battered retaining walls. The vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken that all the joints are full of mortar, well flushed up. In case no pointing is to be done, cement mortar shall be neatly struck as the work proceeds. The joints in faces which are to be plastered or pointed shall be squarely raked out to a depth of 12mm

while the mortar is still green. The rake joints shall be brushed to remove loose particles. After the day's work, the faces of the brick work shall be cleaned on the same day with wire brush and all mortar droppings removed.

4.8.5 Curing

Green work shall be protected from rain or any other running water or accumulated water from any source, by suitable means. Masonry work, as it progresses, shall be kept thoroughly wet by sprinkling water at regular intervals, on all faces. Curing shall be done after 24 hours of completion of day's work and shall be done for atleast 10 days after completion. Proper watering cans with spray nozzles, rubber or PVC pipes shall be used for this purpose.

4.8.6 Staging / Scaffolding

Staging/scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. Design of staging/scaffolding shall be submitted for approval of the Employer, before commencement of work.

Single scaffolding having one set of vertical support, shall be used and other end of the horizontal scaffolding member shall rest in a hole provided in the header course. The support shall be sound and strongly clamped with the horizontal pieces over which the scaffolding planks shall be fixed. The holes left in the masonry work for supporting the scaffolding shall be filled and made good with plain cement concreteof grade 1:3:6 during plastering. Suitable access shall be provided to the working platform area. The scaffolding shall be strong enough to withstand all loads likely to come upon it and shall also meet the requirements specified in IS:2750.

Double scaffolding shall be provided for pillars less than one metre in width or for the first class masonry or for a building having more than two storeys. The following measures shall also be considered during erection of the scaffolding/staging.

a) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.

b) Adjustable bases to compensate for uneven ground shall be used.

c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

d) Horizontal braces shall be provided to prevent the scaffolding from rocking.

e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

f) The scaffolding/staging shall be checked at every stage for plumb line.

g) Wherever the scaffolding/staging is found to be out of plumb line, it shall be dismantled and re-erected afresh. Efforts shall not be made to bring it in line with a physical force.

h) All nuts and bolts shall be the clamps/couplings are firmly tightened to avoid slippage.

i) Erection work of a scaffolding/staging, under no circumstance shall be left totally to semiskilled or skilled workmen and shall be carried out under the supervision of Contractor's technically qualified civil Employer.

For smaller works or works in remote areas wooden ballies may be permitted for scaffolding/staging by the Employer at his sole discretion.

4.8.7 Embedment of Fixtures

All fixtures, pipes, conduits, holdfasts of doors and windows etc. required to be built in walls, shall be embedded in plain cement concrete block of grade 1:3:6, at the required positions, as the work proceeds.

4.8.8 Compressible Joint Fillers

Soft board shall be used where specified at joints requested by the Employer. Filler shall be cut to exact widths and shall have all edges neatly trimmed. Fixing of filer shall be strictly in accordance with the manufacturer's printed instructions.

4.8.9 Polysulphide Sealant for Joints

Polysulphide joint sealer or other equal and approved shall be used. Application shall be strictly in accordance with the manufacturer's instructions.

4.8.10 Galvanised Mild Steel Butterfly Wall Ties

For all vertical joints between brick work and concrete galvanised mild steel butterfly pattern wall ties are to be cast in concrete at 400 mm vertical spacing and then built into the mortar bed joints of the wall.

Where specified, both skins of cavity walls are to be built in brickwall, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties and spaced at the rate of one every 600 mm horizontally and 400 mm vertically, staggered every 400 mm verticaly at ends jambs and quoins.

4.9 Bank Protection Work

4.9.1 Preparation of Formation

The bed for the stone pitching shall be excavated to the required depths and compacted, trimmed and shaped to the approval of the Engineer.

When over excavation occurs, it shall be back-filled with compacted gravel with the approval of Engineer at the expense of contractor.

4.9.2 Laying of Geotextile

Geotextile shall be a 100 % polypropylene (PP), continuous filament, needle punched nonwoven geotextile certified by ISO 9001-2000 and shall be laid to the required thickness underneath pitching on slopes.

The fibres shall be needed to form a stable network that retains dimensional stability relative to each other. This shall be resistant to UV degradation and to biological and chemical environments normally found in soils.

The general specification of the polypropylene Non-Woven Geotextile shall be as follows:

Property	Test Method	Units	Requirement (Non-Woven)
Grab Tensile Strength (md/cd)	ASTM D 4632	N	1550
Grab Elongation (md/cd)	ASTM D 4632	%	>50
Tensile Strength (md/cd)	ASTM D 4595	KN/m	23
Tensile Elongation (md/cd)	ASTM D 4595	%	>50
Tear Strength	ASTM D 4533	N	500

CBR Puncture Strength	ASTM D 6241	N	4000
Burst Strength	ASTM D 3786	kPa	3500
Permittivity	ASTM D 4491	sec^{-1}	0.50
Vertical Flow Rate (50mm head)	ASTM D 4491	l/m2/sec	30
Apparent Opening Size (O 95)	ASTM D 4751	micron	70
Ultraviolet Resistance @ 150 hrs [3]	ASTM D 4355	%	>85
Weight	ASTM D 5261	g/m2	400
Thickness	ASTM D 5199	mm	2.0

4.9.3 Laying of Stone Pitching

Stone for pitching shall be granite or other clean, hard, dense and durable rock free from cracks, kaolinised patches, organic or other impurities.

The stone pitching unless otherwise directed shall be started from ground level and shall be placed in layers manually or other methods approved by the Engineer, all to secure a stable mass. Surface irregularities of the slope shall not vary more than 8 cm (3 inches) along the intended slope. All interstices, hollows and inequalities between stones shall be filled with sand, small pieces and wedged up tight with spawl driven in with slight hammering to the approval of the Engineer.

The stone of required size shall be laid in launching appron to the required depth and approved by the Engineer, all to secure a stable mass. All interstices, hollows and inequalities between stones shall be filled with sand, small pieces and wedged up tight with spawl driven in with slight hammering to the approval of the Engineer.

If the size of stones are not available, the smaller size stones can be laid in wire crates. Wire crates shall be made from hot dip galvanised mild steel wire of dia, not less than 4 mm in annealed condition having tensile strength of 300-450 MPa conforming to IS: 280-1978 (soft). The galvanised coating shall be heavy coating for soft condition conforming to IS: 4826 - 1979. The mesh of crate shall not be more than 150 mm. Wire crates for shallow accessible situations shall be 3m x 1.5 m x 1.25 m in size. Where these have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting.

For deep or inaccessible situations, wire crates can be made smaller subject to approval of the Engineer. Wire crates built in-situ, shall neither be larger than 7.5 m x 3.0 m x 0.6 m nor smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals not exceeding .1.5 m to prevent bulging.

The netting shall be made by fixing a row of spikes on a beam at a spacing equal to the mesh. The beam must be a little longer than the width of netting required. The wire is to be cut to lengths about three times the length of the net required. Each piece is bent at the middle around one of the spikes and the weaving commenced from one comer. A double twist shall be given at each inter-section. This twisting shall be carefully done by means of a strong iron bar, five and half turns being given to the bar at each splice.

The bottom and two ends of the crate or mattress shall be made at one time. The other two sides shall be made separately and shall be secured to the bottom and the ends by twisting

adjacent wires together. The top shall be made separately and shall be fixed in the same manner as the sides alter the crate or mattress has been filled. Wherever possible, crates shall be placed in position before filling with boulders. The crates shall be filled by carefully hand packing the boulders as tightly as possible and not by merely throwing in stones or boulders.

4.9.4 Laying of Stone Pitching under water

The stone pitching work shall include stone pitching on design bank slope and in launching approne on river bed. A part of stone pitching work is required to be carried out under water. The stone pitching work under water is done from land side using sand benching or from the water side using barge mounted cranes.

Procedure for Bank Protection works below LWL

The main objective of shore protection works is to give efficient protection against scouring of soil and giving minimum hindrance to water flow. At Kalughat location Low water Level is +42.0m ,Average Bed Level is +39.5m and Depth below LWL is 2.5m. The existing river bed slope is 1V to 4H flatter than proposed slope of 1V:3H calling for filling. The toe of the rock bund is below water. To constuct toe or launching apron under water there are two methods of construction.

Method-1: From land side using sand benching.

Method-2 : From the water side using barge mounted cranes.

1. Under Water Installation of Mattress Using Crane on Shore

In this case of installation of launching/ toe apron can be laid directly on existing flatter ground or by cutting and filling as shown in the drawing I-525 KGT-226. the apron will be launched with the help of crane place on benched soil. Typical launching of apron from shore is shown in the below pictures.

In case of installation of part of the revetment under water, the units can be easily prefilled in dry conditions and installed using very simple cranes.

2. Under Water Installation of Mattress from water side Using Crane and Barge

In this method the apron will be launched with the help of crane place on barge. Typical launching of apron from river side is shown in the below pictures.

4.10 Container stockyard

This section covers the specification for the construction of container stockyard.

These specifications includes the requirements for the preparation of base and surfacing courses in accordance with these specifications and in conformity with the dimensions shown in the drawings and with the lines and grades established by the Contractor at site subject to approval by the Employer.

The pavements such as concrete block pavement, with easy maintenance shall be provided as required. These pavement must be laid over base course that will distribute and transmit the loads to the under laying soil causing the least possible differential settlements.

The pavement shall be graded to allow the cargo handling equipment to operate at their optimum rates and to allow for storm water to the drainage system.

The specifications for earth filling , preparation of sub base and base courses and laying of concrete block pavement shall be followed as provided for internal road works in section4.5.

4.11 Structural Steel Work

4.11.1 General

This section includes requirements of all structural steel work required for the completion of the Works, as shown on the drawings and as specified herein.

All structural steel used by the Contractor for the construction shall conform to relevant IS codes or equivalent as approved by the Employer and described in this specifications. If deviation or a substitution of material is sought, the Contractor shall submit written request to Employer along with necessary supporting documents including test results, manufacturer's certificate, etc. along with reasonable time for evaluation without disruption of the construction schedule. It shall be the Contractor's responsibility to satisfy

the Employer that his proposed deviation or substitution will in no way be detrimental to the quality of the works intended in the Contract. In case of any doubt the Employer may ask for additional information, testing or retesting which the Employer may feel necessary, which the Contractor shall carry out to the Employer approval and with no impact on the construction schedule.

It shall be noted that site fabrication and painting of steel members shall not be allowed. The Contractor has to make his arrangements accordingly.

4.11.2 Structural Steel

4.11.2.1 Steel Grades

Unless otherwise stated all steel shall conform to one of the following grades.

a) Carbon Steel: ASTM A 36 or approved equivalent (Fee=36 Ksi) IS 2062 Gr A

b) Intermediate strength steel: BS 7191 Gr 355D, API Spec.2 H Gr 50 or

APPROVED EQUIVALENT (FY=50kSI)

Steel supply to specifications equivalent to those listed above shall be considered as substitution and shall require written approval by Employer to this effect.

4.11.2.2 Structural Steel Types

Rolled Shapes and Plates

All rolled shapes and plates shall be carbon steel grades as defined and unless otherwise specified.

Tubulars

All Tubulars shall be fabricated in accordance with API Spec. 2B, from plates which should conform to one of the steel grades indicated in Clause (i) above.

Mill - manufactured line pipes, where acceptable shall be of prime quality and shall conform to API 5L Gr. B or equivalent, seamless.

The use of spirally welded and electric resistance welded pipes shall not be permitted for any load bearing structural member.

i) Usage

The usage of different grades of steels shall be as determined by design. For jacket type structures (if used by Contractor), the guidelines of API RP 2A shall be followed for material usage.

ii) General Requirements

a. Process

The steel shall be manufactured by the basic open hearth, electric furnace or basic oxygen process. No rimmed or capped steel shall be used.

b. Delivery, Storage and Handling

All rolled shapes and plates are to be delivered in accordance with ASTM A6, "Standard Specifications for General Requirement for Rolled Plates, Shapes sheet piling and bars for structural use".

Fabricated Tubulars shall conform to the dimensional tolerances of API Spec. 2B, "Specifications for Fabricated Structural Steel Pipe". For mill manufactured pipes, where permitted for use, dimensional tolerances of API Spec. 5L, "Specification for Line Pipe", shall apply with additional requirements for straightness listed in API Spec. 2B.

All structural steel shall be stored and covered in a manner which will ensure that no damage shall occur to it from moisture, dirt, grease or any other cause which might impair bond with concrete.

a. Identification

A sufficient supply of approved structural steel shall be stored at the site at all times to ensure that there will be no delay of the work.

Steel will be reasonably free from defects, mill scale and rust.

Structural steel shall be bundled and tagged with grades, size and suitable identification mark for checking, sorting and placing size and mark numbers. Tags and markings shall be waterproof and shall not be removed until steel is placed.

b. Mill Tests

All mandatory inspection and testing listed in ASTM A6, "Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural Use", shall apply. Supplementary inspection and tests when specified in individual specifications shall also apply. In addition to above for all steel materials the following are mandatory requirements:

Product Analysis: One sample per heat. Acceptability standards as specified in ASTM designation A6 shall apply for all elements.

In addition, a field weldability test shall be performed in accordance with the requirements of relevant IS codes or equivalent with a heat input of 15–20 kj/cm and the results of the test shall meet the requirements specified for the base material. This requirement shall be a prerequisite for the acceptance of the material.

c. Mill Certificates

Contractor shall supply the Employer with a certificate indicating the process of manufacture, results of chemical and mechanical tests including specified supplementary tests for the material. Each test certificate shall bear the heat number and other identifidation marks such that the same can be correlated with the material. These certificates shall be signed by manufacturer’s representative and furnished alongwith material.

When any steel is supplied from stock, the Contractor shall satisfy the Employer that the steel has been manufactured and tested and complies with all the tests and requirements of the specification under which the steel is being furnished with necessary documentary proof of original manufacturers. The heat numbers on mill certificates should be correlated with markings on the material. Steel material without acceptable mill certificate shall not be used.

i. Special Requirements

a. Carbon Steel

All carbon steel material shall meet the following:
Max. Carbon (Cmax) = 0.22%
Max. Carbon Equivalent (CE) = 0.45
(For CE formula refer 2.5.2)

b. Intermediate Strength Steel

The carbon equivalent shall be a maximum of 0.43 (ladle analysis) as determined from the following formula:

$$CE = C + \frac{Cr + Mo + v}{5} + \frac{Cu + Ni}{15} + \frac{Mn}{6}$$

V less than or equal to 0.08%
Nb less than or equal to 0.05%
V+Nb less than or equal to 0.10%.

i. Other Requirements

All plates shall be ultrasonically inspected for defects and discontinuities in accordance with ASTM A578. Acceptance Standard shall be level II.

If intended to use plates having defects requiring repair for welding procedure qualification, these plates shall be shipped clearly marked "For Welding Procedure Qualification Only".

ii. Heat Treatment

Heat Treatment shall be performed on all elements where properties have been degraded by forming and fabrication.

The use of furnaces is desirable for all heat treatments. When local heat treatments are deemed necessary, a detailed procedure shall be submitted to the Employer for approval prior to performing such heat treatments.

Stress Relief

Stress relief heat treatment shall be performed on all materials subject to the following conditions:

- Elements subjected to press or roll forming where the temperature of the steel is above 38°C or less than 427°C during the forming operation.
- Elements subjected to press or roll forming where the outer fiber strain exceeds five (5) percent as defined by the formula:

  $$\text{Percent Strain} = \frac{100\ t}{D}$$

  Where t = thickness of element
  D = outside diameter
- Welded assemblies containing one or more elements with the thickness exceeding 65 mm.

Stress Relief Temperatures

All stress relief shall be achieved by thermal methods by heating the element or assembly to a temperature between 590°C to 620°C for carbon steel and intermediate strength steel.

4.11.3 Quality Control

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. Materials or workmanship shall meet with the provisions of specifications and approval of Employer.

Before start of work, Contractor shall submit a detailed quality control plan of fabrication and erection for Employer's approval. Such QC plan shall include inter alia, the welding

process proposed, type of electrodes to be used, acceptable criteria to be used for error in erection etc.

The quality control procedure/operations shall cover but not be limited to the following items of work:

- Bolts, Nuts and Washers: Manufacturer's, certificate, dimension checks, material testing
- Electrodes: Manufacturer's certificate, thickness and quality of flux coating
- Welders: Qualifying Tests
- Welding Sets: Performance Tests
- Paints: Manufacturer's certificate, physical inspection reports regarding quality of paints, primers & thinners.
- Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
- Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.
- Painting: Preparation of surface for painting, application and uniformity of coats.

4.11.4 Fabrication

The Contractor shall prepare detailed drawings giving complete information necessary for the fabrication of the steel works. All information should be clearly given and the drawings shall be in conformity with the best modern practice. A marking diagram allotting distinct identification marks to each separate piece of steel work shall be prepared in sufficient detail to ensure convenient assembly and erection. Symbols for welding used on the drawings shall be in accordance with IS:813 "Scheme of Symbols for Welding".

The Contractor shall prepare comprehensive bill of material sheets for each shop drawing giving therein all the items shown on the drawings together with their weights, mark numbers, cutting lengths, etc. All fabrication shall be in accordance with IS:800 "Code of Practice for use of Structural Steel in General Building Construction".

4.11.5 Welding

Metal arc process shall be used for welding in all cases, unless otherwise specified by the Employer. The welding procedure shall be in accordance with the requirements of IS:816 "Code of Practice for Use of Metal Arc Welding for General Constructions in Mild Steel". The symbols for welding as shown on the drawings will be interpreted in accordance with IS:813.

Electrodes used for hand welding or for automatic welding machine shall conform to IS:814 "Covered Electrodes for Metal Arc Welding of Structural Steel".

4.11.6 Galvanising

Galvanising where specified shall be of the best quality conforming to IS:2629 "Recommended Practice for Hot Dip Galvanising of iron and Steel".

4.11.7 Installation

Install in locations shown, as indicated on Contractor's drawings, to line, plumb, and level, rigidly attached in placed with all connections to other work neatly made and drawing up tight. Joints caulked to provide weather-proof installation. Erection equipment shall be suitable and safe for the workmen. Errors in shop fabrication or deformations resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be reported immediately to the Employer and approval of the method of correction shall be obtained.

Anchor bolts and anchors shall be properly located. After assembly the various parts of a completed frame or structure shall be aligned and adjusted accurately before being fastened. As erection progresses, the work shall be accurate fastened to take care of all dead loads, wind and erection stresses. Unless removal is required all erection bolts used in welded construction may be tightened securely and left in place. Drilling may be used in such a manner as not to distort or damage the metal. The use of gas-cutting torches in the field for connecting fabrication errors will not be permitted on any major member of the structural framing.

4.11.8 Bolting

Bolts shall be driven accurately in holes without damaging the thread. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Where bolts are to be used on bevelled surfaces, bevelled washers shall be provided to give full bearing to the head or nut.

4.11.9 Shop Painting

Paint all surfaces, except those to be embedded in concrete with exterior ferrous metal primer on properly prepared surfaces, as specified under 'Painting'. Surfaces which will be embedded in concrete shall not be painted but shall be cleaned as required for painting.

4.11.10 Inspection & Testing

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Employer to carry out inspection and/or tests in accordance with the Contract. The Contractor shall guarantee compliance with the provisions of this specification.

The Contractor shall carry out sampling and testing in accordance with the relevant British Standards or equivalent as directed by the Employer, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Employer and submit to Employer the test results in triplicate within 3 (three) days after completion of the test.

4.12 Steel/Aluminium Doors, Windows and Ventilators

4.12.1 General

This section of the specification includes the requirements necessary to provide in place all steel/Aluminium doors, windows and ventilators.

4.12.1.1 Indian Standards

IS 6248	Specification for metal rolling shutters and rolling grill
IS 1081	Code of practice for fixing and glazing of metal (steel and Aluminium) doors, windows and ventilators.
IS 4351	Specifications for steel door frames.
IS 1948	Specifications for Aluminium doors, windows and ventilators.
IS 1361	Specifications for steel windows for Industrial buildings.
IS 1038	Specifications for steel doors/windows and ventilators.
IS 1200 (Part XIV)	Method of measurement of glazing.
IS 3614	Specifications for fire check doors.

IS 7452	Specification for hot rolled steel sections for doors, windows and ventilators.
IS 2835	Flat transparent sheet glass.
IS 5437	Wired and Figured glass.
IS 25583	Safety glass.

4.12.2 Pressed Steel Door/Window/Ventilator Frame

Pressed steel door/window/ventilator frame shall confirm to IS:4351.

The frames shall be made of 16gauge pressed steel bent to shape using bending machine, and mitred with square edges. The frames shall be provided with spacers by welding 50 mm x 5 mm flats to the portion of the frame in contact with the wall jambs @ 600 mm vertical spacing.

The frame shall be fixed to the masonry by means of 300 mm x 25mm x 6mm hold fast welded to the spacers and grouted with M-20 grade concrete in minimum 350 mm x 100 mm x 100 mm sized hole in the masonry. In case of concrete, the frames shall be fixed by 96 mm long, 12 mm dia metallic counter sunk type dash fasteners through the frame and spacers.

Provisions for hinges, locking arrangement and other hardwares shall be provided in the frames by machine cutting required size cutout on the frame body and welded / screwed to 3 mm thick M.S. pad plates-already welded over the cut out from behind.

The frame surface shall be thoroughly cleaned of rust, mill scale, dirt, oil etc. and then finished with painting (by priming with red oxide zinc chromate primer conforming to 1S:2074 and painting on forming to 1S:1477 Part (II) or by approved shade electrostatic powder coating (25 micron).

4.12.3 Pressed Steel Door Shutter

Pressed steel shutters shall be hollow type with 18gauge pressed steel welded at meeting of the sheets with pad plate of M.S flat 3 mm thick all along perimeter. The cavity shall be packed with rigid phenolic foam board adequately cut into shape to fully fit into the box cavity without gaps.

The shutter shall be formed by machine bending of 18 gauge (as specified in item) pressed steel sheet in form of hollow box making an overall thickness of 40mm forming truly square edge in accordance with the shutter profile. It shall further be braced with channel shaped horizontal stiffeners formed by folding 16 gauge MS sheets (35mm wide) @ 500 mm max. And fixed by flush riveting. 3mm thick M.S. pad plates shall be welded inside at required locations for fixing of hardwares such as tower bolt, aldrop etc.

For double shutter doors, an M.S. angle 25mm x 45mm x 3 mm thick shall be welded to one of the shutters providing a minimum 25mm wide rebate for the other shutter at the meeting point during closed condition.

The shutter surfaces shall be painted with electrostatically powder coating/two coats of synthetic enamel paint over a priming coat of red oxide zinc chromate conforming to IS 2074/IS 1477 (Part-11). The shutters shall be fixed to the door frame by means of heavy duty MS butt hinges of 150mm size conforming to table 6 of IS 1341 @ 600mm max.

In case of air tight door shutters, approved quality continuous neoprene rubber beading shall be provided continuously along the door frame rebate fixed with neoprene rubber adhesive of approved make.

In case of partly glazed door shutter. Glassas specified shall be fixed with glazing clips and solid drawn 10 mm x 10 mm, MS beading backed with putty and fixed by countersunk screws. Necessary rebate for fixing the glass shall be provided by arranging the shutter bracing accordingly.

The shutters shall be provided with locking device, handles and other hardwares as specified.

4.12.4 Steel Windows & Ventilator

Steel windows, ventilators shall in general conform to IS 1081, IS 1038,IS 7452.

4.12.4.1 Materials

Rolled Steel Sections

Rolled steel sections for the fabrication of steel windows, ventilators shall conform to IS 7452.

Glass Panes

Glass panes for glazing purpose shallbe as specified in item description. All glass panes shall have property squared corners and straight edges. Glass panes shall be of following types in accordance with item description :

i) 4 mm thick transparent sheet glass conforming to IS 2835 (wt. 7.2 kg/m)

ii) 5.5 mm thick wired glass conforming to IS 5437.

iii) 6.3 mm thick laminated safety glass conforming to IS 2553.

Workmanship

The profile and type of windows, ventilators (glazed, partly glazed/louvered, side hung/top hung/fixed shutter, composite) shall be as per Contractor's drawings.

The frames shall be fabricated of sections cut to size and metered. Corners shall be welded to form a fused welded joint. Process of welding shall be flash butt welding. The welded joints shall be grinded to square and flat edges.

Where larger units are to be formed by coupling individual units, the mullions, transoms shall be bedded in mastic to ensure weather tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembly, and the two units being coupled shall be drawn together tight with clamps, the mastic being squeezed out and cut off neatly when the units shall be screwed together tight. Where fixed glazing units are placed over openable units a push fit weather bar shall be provided.

Before glazing, all opening parts shall be checked for their operational smoothness. The frame shall be completely cleaned and bedding putty shall be placed in the rebate before glazing. Glass then shall be cushioned into the bedding and shall be fronted with front putty in a manner so as to enable the painting to be done upto the sight line. The back putty oozing out over the glazing rebate shall be cut off square and smoothed down.

For panes exceeding 600 x 300 mm in size, glass shall be secured by special glazing clips inserted in holes already provided in the steel sections, before applying the front putty.

For glazing of very large areas, rust proof steel beading with metered corners shall be provided with screws @ 10 cm. from each corner and @ 20 cm. apart from each other. Putty shall be provided to the face of the bead in contact with glass, in addition to back putty.

Side hung shutters shall be connected to the frame by means of friction hinges. The handle for side hung shutters shall be of pressed brass mounted on a steel handle plate welded to the opening shutter frame and shall not be removable easily after glazing. The handle shall

have a two point nose which shall engage with a brass striking plate on the fixed frame in a slightly openas well as in a fixed position.

Top hung shutters shall be provided with steel butt hinges welded to the fixed frame after cutting a slot in it. Top hung casements shall be provided with peg stay of 3 holes of pressed brass, 300 mm long which when closed shall be held tightly by the locking bracket fitted to the fixed frame or to the window.

Before fixing the frames, the size of the opening shall first be checked and cleaned of all obstructions. The positions of the unit in the reveal shall be taken off and shall be marked on the reveal at the jambs using a plumb line. In case of fixing with masonry, holes for fixing the lugs/hold fasts shall be cut at required locations. In case of concrete or stone, the frames shall be fixed by means of dash fasteners. In case of masonry, the lugs shall be grouted in the holes with cement concrete, M-15 Grade when fixing to steel work, mastic shall be applied to the sill of the opening and the unit shall be placed on it with the jambs and head buttered with mastic and the unit shall be fixed with special fixing dips or with nuts and bolts.

The windows/ventilators shall be checked to ensure smooth operation, perfect level and plumb.

All the steel surfaces shall be thoroughly cleaned free of rust, mill scale, dirt, off etc. by sand and shot blasting and then finished with painting by priming with red oxide zinc chromate primer conforming to IS 2074 and painting conforming to IS 1477 (Part II) or by hot dippedgalvanizing confonning to IS 1477 Part (I). Putty shall also be provided with painting in a manner so as to seal the putty glass junction. Surfaces not meant for painting shall be cleaned of any strains of paint.

4.12.5 Rolling Shutters

4.12.5.1 General

Rolling shutters shall be of best quality conforming to IS 6248 - 1979 and obtained from approved make. These shall include necessary locking arrangement and handles, fixing bolts, safety devices, anchoring rods etc. These shall be suitable for fixing in position as specified i.e. outside or below lintel or between jambs of the opening. The door shall be push and pull type and also operated with chain crank as required. Electrically operated rolling shutters shall be used wherever specified.

4.12.5.2 Galvanising

All M.S. materials including lath sections, clips, guides, lock plate, guide channel, bracket plate, suspension shaft hood cover& other components shall be hot dip galvanised with a zinc coating containing not less than 97.5percent pure zinc. The weight of the zinc coating shall be not less than 750 mm/m^2 both sides and the coating shall be free from flaking or peeling conforming to IS:1477-1977 (Part I& II).

4.12.5.3 Shutters

The shutters shall consist of M.S. lath sections conforming to IS 513-1986, 1.25 mm thick and 75 mm wide unless otherwise specified. The laths shall be machine rolled and straightened with an effective bridge depth of not less than 16 mm and shall be interlocked together throughout their entire length and joined together at the end with end locks by means of cast iron or galvanised mild steel clips conforming to IS 2108-1977 riveted at either end which shall prevent lateral movement of the individual lath sections. These shall be mounted on specifically designed pipe shaft. Each lath section shall be a continuous single strip piece without any joint.

4.12.5.4 Springs

The springs shall be, preferably of coiled type. The spring shall be manufactured from high tensile spring steel wire conforming to grade 2 of IS 4454-1981 or strip of adequate strength to balance the shutters in all positions. The spring pipe shaft etc. shall be supported on strong mild steel brackets.

4.12.5.5 Guide Channels

The guide channels shall be of mild steel deep channel section and of rolled, pressed or built-up construction. The thickness of the sheet used shall not be less than 3.15 mm. The minimum depth of guide channels shall be 60 mm for clear width of shutters upto 3.5 m and 75 mm for 3.5 m and above guide.

The gap between the two legs of the guide channel shall be sufficient to allow free movement of the curtain and at the same time close enough to prevent rattling of the curtain due to wind. Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the walls or columns by means of heavy duty bolts or screws. The guide channels shall be attached to jambs, in plumb either in the overlapping or projecting torsion or embedded in grooves, depending on method of fixing to the approval of the Employer.

4.12.5.6 Fixing

Brackets shall be fixed on the lintel or under the lintel as shown with metal fasteners, screws, bolts, etc. The shaft along with the spring shall then be fixed to the brackets.

The shutters shall be laid on the ground and the side guide channels shall be bound with it with ropes etc. The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels and the cover frame shall then be fixed to the walls through the plate welded to the guides.

Fixing shall be done accurately in workmen's-like manner so that the operation of the shutter is easy and smooth.

4.12.5.7 Grilled Curtain

Wherever specified rolling shutter shall be provided with grilled curtain partly or fully, as required.

4.12.5.8 Electrical Devices

Suitable electrical devices, push buttons, etc. shall be provided at suitable location to control the opening and closing the rolling shutter. Suitable limit switches shall be provided to automatically stop motor when shutter reach the fully open and closed positions. The control switchgear, cabling, etc. should be of reputed make, conforming to relevant IS codes.

4.12.6 Aluminium Glazed Doors/Windows/Ventilators

4.12.6.1 General

Aluminium glazed doors/windows/ventilators shall be of specified sectional size, dimension and profile as per Contractor's drawing.

4.12.6.2 Materials

All Aluminium sections shall be extruded sections of INDAL aluminium alloy as per IS:733 and 18:1285. Aluminium sections shall be anodised as per IS : 7088 to min. 25 microns.

Glass used for glazing shall be of following type in accordance with item description.

i) 5.5 mm thick wired glass conforming to IS 5437.

ii) 6.3 mm thick laminated safety glass conforming to IS2553.

iii) 5.5 mm thick transparent sheet glass conforming to IS 2835 (wt. 72 kg/sq.M)

4.12.6.3 Workmanship

Frames shall be square and flat, the comer of the frame being fabricated to true right angles. Details of construction of frames. shutters etc. shal be as per drgs.

Side hung window shutters shall either be fixed to the frame with pivots, or aluminium alloy hinges. For fixing the hinges, slots shall be cut in the fixed frames and the hinges inserted inside may be riveted to the frame. The hinges shall normally be of the projecting type conforming to IS designation A-5-M of IS 617, IS 733. In which case Peg stay of 300 mm long complete with Locking bracket and conforming to IS codes same as for hinges shall be provided. Friction hinges may also be provided in which case peg stays are not required.

The handles for side hung shutters shall be of cast aluminium conforming to IS designation A-5-M of IS 617 and shall be mounted on a handle plate rivetted to the opening frames. The handle shall have anodised finish with minimum anodic film thickness of 25 micron or electro colour finish. The handle shall have a two-point nose which shall engage with an aluminium striking plate on the fixed frame. The striking plate shall be finished in the same manner as for the handle. In case of top hung shutters, aluminium alloy cast hinges and peg stays (same as per side hung shutters) shall be provided.

Centre hung shutters shall be hung on the two pairs of cup pivots of aluminium alloy of IS designation NS-4 of IS 737 and IS designation A-5-M of IS 617 or chromium/cadmium plated brass/bronze cup pivots riveted to the outer and inner frames to permit to swing through an angle of 85°. Cast aluminium (conforming to IS designation A-5-M of IS 617) or chromium/cadmium plated bronze spring catches shall be fitted in the centre of the top bar of the shutter. The spring catch shall be secured to the frame by screwing/riveting to the frame and shall close into an aluminium catch plate riveted/welded to the outside of the outer shutter frame bar. Aluminium or cadmium plated brass chord pulley wheel in an aluminium bracket shall be fitted at the sill of the shutter with Aluminium or galvanized/cadmium plated steel screws.

The door shutters shall be fitted with pivots as specified. The handle for doors shall be of Aluminium and as per design. The door shutters shall be provided with locking device, floor spring. 0/H door closer and any other hardwares, specified in item.

In case of composite Door/window/ventilator units, the units shall be coupled. Weather bar shall be provided whenever a couping member is fitted over an external opening shutter. Glazing shall be fixed to the extruded sections by means of extruded aluminium beading. Glass panes shall be provided with rubber lining before fixing.

The aluminium frames shall be fixed to the masonry by means of aluminum lugs fixed to the frame (by counter sunk gatvanished machine screws) and grouted with M-15 grade concrete in the hole in the masonry. In case of concrete wall, the frames shall be fixed by 96 mm long, 12 mm dia metallic dash fasteners. Any steel material coming in contact with aluminium shall be galvanised.

The windows/ventilators/doors shall be checked to ensure smooth operation, perfect level and plumb.

4.13 Steel Sheet Roofing and Siding

4.13.1 General

This section includes all labour materials, and equipment necessary to furnish in place all steel roofing and siding, all flashings, closers, and accessories used in conjunction with the siding to make a weather tight installation and related hardware and fasteners required for completion of this Contract and as herein specified.

The Contractor shall supply, deliver and fix everything necessary to complete the installation of roofing, cladding in accordance with the specification.

The roof slope in general shall not be flatter than 1:5. The normal pitch if not specified shall be 1:2. Materials shall be from an approved manufacturer. The items supplied shall be free from cracks, chipped edges or corners or other damages. Storage and safety precautions shall be taken to avoid damage to the accessories.

Reference shall be made to the following Indian Standards:

- IS 277: Galvanised steel sheet (plain& corrugated)
- IS 730: Hook bolts for corrugated sheet rooting.
- IS 459: Specification for unreinforced corrugated and semi corrugated asbestos cement sheets.
- IS 1230: Cast iron rainwater pipes & fittings.
- IS 1728: Specification for sheet metal rain water pipes upto 100 mm nominal size gutters, fittings and accessories.

4.13.2 Materials

4.13.2.1 Corrugated GI Sheet Roofing / Cladding

Corrugated GI sheet

G.I. sheets shall be of specified thickness and of class-3 galvanised as per IS 277 and shall be of approved brand by the Employer. The thickness of the sheets shall be worked out based on the wind speed expected in the project area.

GI Ridges and Hips

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and dimensions as per Contractor's drawings without damaging the sheet in the process of bending.

GI Valleys and Flashings

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and size as per Contractor's drawings without damaging the sheet in the process of bending.

GI Gutters

These shall be of specified thickness and of class 3 plain galvanised and shall be constructed to the required shape and size as per Contractor's drawings.

Wind Ties

Wing ties of mild steel shall be as per requirement of the design.

4.13.3 Workmanship

4.13.3.1 Corrugated GI Sheet Roofing

Spacing of Purlins

One purlin each shall be provided at the ridge and the eaves. Spacing of the purlins shall be as per the requirement of the design. Purlin shall coincide with the centre line of the end lap. Ridge purlin shall be placed such that ridges can be placed properly. Portion overhanging the wall support should not be more than one fourth the purlin spacing.

Finish for Purlins

The top surfaces of the purlins shall be painted before fixing the sheets and the embedded portion shall be finished with two coats of coal tar.

Laying of sheets

Sheets shall be laid on the purlins to a true plain with the lines of Corrugation truly parallel or normal to the sides of area to be covered, unless otherwise specified. They shall be bent up along their side edges close to the wall and the junction shall be protected by flashing on projection drip course as specified.

Laps

End laps shall be 150 mm for 1:2 slope and 200 mm for flatter ones. Side lap shall be of two ridges of corrugations on each side.

Cutting of Shaft

Sheets shall be cut according to the dimensions. Sheets shall be cut with a straight edge and chisel to give a straight finish.

Fixing of sheets

The sheets shall be fixed to the roof members with J or L polymer coated bolts, polymer cap, seal washer and thrust washer. The bolts shall be long enough to project at least 12 mm above the top of their nuts. The grip of J or L hook bolts on the side of purlins shall not be less than 25 mm. There shall be at least three hook bolts placed at the ridges of Corrugations in each sheet in every purlin and their spacing shall not exceed 300 mm. Sheets shall be joined together at side laps by polymer coated bolts and nuts as specified, each bolt with a polymer cap (grease filled) steel washer and polymer coated thrust washer. Bolts shall be placed zigzag on overlapping Corrugations. The spacing of the beam bolts shall not exceed 600 mm in each of the staggered rows.

Holes

Holes for all bolts shall be drilled in the ridges of the corrugations from the underside before placing in position. The holes in the sheet shall be at least 50 mm from the edge. The holes in the washers shall be of diameter of the hook bolts or the seam bolls. The nuts shall be tightened from above to give a leak proof roof.

Ridges and Hips

The overlap for ridges and hips on either side of C.G.I, sheet and end legs shall be at least 225 mm. Ridges & hips shall be fixed to the purlins with polymer coated hook bolts, thrust washer and polymer cap. At least one of the fixing bolts shall pass through the end laps of ridges and hips on either side. If it is not possible extra hook bolts shall be provided. Each end-lap of ridges and hips shall be joined together by at least galvanised iron seam bolts and GI washers. Ridges and hips shall fit squarely on the sheets.

Valleys and Flashings

The edge, wherever the roof sheeting or valley gutter is turned up against a wall shall be made weather proof with flashing. Flashing shall be bent to shape and fixed as specified. Lap over the sheet shall be minimum 150 mm. End laps between flashing sheets shall not be less than 225 mm.

Flashing shall be inserted into brick work or masonry joints to a depth of 50 mm and shall be filled with cement mortar (1:3). When flashing has to be laid at a slope, it shall be stepped at each course of masonry. The steps shall be cut back at an angle of at least 30°.

Valleys shall be bent to shape and shall have at least 225 mm end lap and projection on either side under CGI sheet. Valleys shall be fixed to the root members below with polymer coated GI bolts, polymer cap, seal washer and polymer coated thrust washer. At least one fixing bolt shall pass through end laps of the valley piece.

Gutters

The longitudinal edges shall be turned back by 12 mm and beaten to form a rounded edge. The ends of the sheet at junctions of pieces shall be hooked into each other and beaten flush avoid leakage. Gutters shall be laid to minimum 1:120 slope. Gutters shall be true to line and slope and shall be supported by brackets as specified.

Wind Ties

Wind ties shall be of 40 mm x 6 mm flat iron section and other size as specified. These shall be fixed at the two eaves end of the sheet. Fixing shall be done with the same loose bolls which secure sheets to the purlins. Slot holes shall be cut in the wind ties to allow for temperature variations.

4.13.3.2 Precoated Galvanized Sheet Roofing / Cladding

Material

The base metal of the roofing shall be Cold Reduced Steel Sheet conforming to IS-513. It shall be galvanised by Hot-dip process as per IS-277. The bottom unexposed surface shall then be coated with alkyd backer of min. 7 microns Top exposed surface shall have epoxy primer of min. 7 microns followed by polyester top coat of min. 16 microns of specified colour.

Properties

The precoated galvanised steel sheets shall meet the following performance standards:

- Pencil Hardness : H-2H
- Formability : 2-3 t
- Impact Resistance : 40"/lb.
- Salt spray test : 750 hours
- QUV-Wealterometer Test : 1000 hours
- Humidity Test : 1000 hours
- Temperature Resistance : 150°C
- Fire performance : Class 1

Profile

The profiles shall have a depth of not less than 35mm and pitch of 190mm. Overall sheet thickness shall be 0.65mm min. and weight shall be 5.72 kg/sqm.

Accessories

All roofing accessories like ridge, gutters, north light curves etc. shall be fabricated out of the approved pre-coated sheet.

Metallic Fasteners and Fixing accessories shall be corrosion proof. Non-metallic fasteners shall be of neoprene. Sealants shall be neutral cure type and cold setting variety

4.14 Wood Work

4.14.1 General

This section of the specification includes requirements for furnishing and installing all wood work including iron mongery as specified for the completion of all of the work of the Contract.

The Contractor shall supply all timber, fittings, ancillary materials for fixing such as glue, screws, bolts, hold fasts etc. required for the works all in accordance with dimensions and sizes required.

The Contractor shall ensure that any timber entering the site for incorporation in the permanent works is of an approved quality. Pre-fabricated & assemble doors, windows and / or any other unit shall on arrival at the site, be subjected to a thorough inspection and approval by the Employer.

Timber for joinery work shall be wrought to the exact sizes and all surfaces shall be rubbed down and left clean for painting or staining.

4.14.1.1 Indian Standards

IS:2202-Part I	Specification for wooden flush door shutters (solid core type) plywood face panels
IS:2202-Part II	Specification for wooden flush door shutters (Solid core type) practice board and hard board face panels.
IS:1003 Part - I	Specification for Timber panelled and glazed shutters -Door shutters
IS:3087	Specification for wood particle boards (medium density) for general purposes
IS:3097	Specification for Veneered particles board
IS:848	Specification for synthetic Resin Adhesives for plywood (phenolic and Amino plastic)
IS:205	Specification for non ferrous metal butt hinges
IS:2338	Code of Practice for finishing of wood and wood based materials (Part-1& Part-11)
IS:1341	Specification for steel butt hinges
IS:4021	Specification for timber door, window and ventilator frames
IS:303	Specification for plywood for general purpose

4.14.2 Material

4.14.2.1 Timber

Teakwood

Teakwood shall be second class Indian Teakwood conforming to IS:4021 of good quality, well-seasoned and free from defects such as cracks, dead knots, sapwood etc. No individual hard and sound knot shall be more than 15 sq.cm in size and the aggregate area of such knots shall not exceed 2% of the areas of the piece. The timber shall be fairly close grained having not less than 2 growth rings per cm, width in cross-section.

Hard Wood

Hard wood shall be first class wood conforming to 1S:4021 of good quality, well-seasoned and free from defects such as dead knots, cracks, sapwood etc. No individual hard and sound knot shall exceed 6 sq. cm in size with no dimension more than 50 mm and the aggregate area of such knots shall not be more than 1% of the area of the piece. There shall not be less than 5 growth rings per cm, width in cross-sections.

Moisture Content in Timber

The maximum permissible percentage of moisture content for well-seasoned timber shall be as per IS 287.

Workmanship of Wood Work

Workmanship for wood and joinery shall be as per 1S:1200 and IS:4021.

Painting / Polishing of Wood Work

Painting/polishing of wood work shall be in accordance with specifications under 'Painting'.

4.14.3 Wooden Door / Window Frame

Wooden Door / Window frame shall be made of specified wood as per item description and shall be in accordance with detailed drawings of Contractor.

The wooden members of the frame shall be planed smooth and accurate to the full dimensions. Rebates, rounding, moulding etc. shall be done before the members are jointed into frames. Joints in the frame work shall be perfect with square edges and shall be pinned with hard wood/bamboo pins of 10 to 15 mm dia.

Wood work shall be painted/polished or otherwise treated as specified. All exposed portions shall be coated with wood primer and concealed surface by bituminous paints as per specifications under 'Painting'.

Before any surface treatment is applied, the wood work shall be got approved by the Employer. The frames shall be fixed only after acceptance by the Employer. The frames shall be fixed to the masonry by 300 mm x 25 mm x 6 mm MS hold fasts embedded. In M-15 grade concrete block of 350 mm x 100 mm x 100 mm in the hole of the masonry. In case of concrete, frames shall be fixed by 96 mm long 12 mm dia metallic dash fasteners.

4.14.3.1 Shutters

Particle Board Flush Shutter

Particle board flush shutter shall in general conform to IS:2202.

Materials

i) Particle Board

Panicle board shall conform to IS 3097 and shall be three layer flat pressed teakwood based and of exterior grade (Grade-1), type-1, BWP type bonded with phenol Formaldehyde synthetic resin conforming to IS 848.

ii) Veneers

Veneers shall conform to class-I ofIS:303 and (BS:476 Part-7)

iii) Teakwood

Specification of Teakwood shall be same as specified in Clause 4.12.2.1 of this section.

iv) Hinges

Hinges shall be of Extruded Aluminium Alloy and butt type conforming to IS:205. Size of hinges shall be in accordance with shutter width and as per IS:205.

Workmanship

The particle board of required size and thickness shall be lipped on all the edges with T-type teakwood lipping. The overall board lipping composition shall be of uniform and specified thickness and shall be property sized in view of the operation of shutter.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed. The shutter then shall be veneered on both faces by gluing approved shade and textured commercial type 0.5 mm thick veneering conforming to class 1 of IS 303.

The veneering shall be done by gluing the veneer with BWP type, phenol formaldehyde synthetic resin conforming to IS 848 by hot press process on the shutter. Workmanship and finish of the veneering shall conform to IS 303.

The exposed surfaces of the lipping of the edges shall be French polished in accordance with specifications under 'Painting'. The shutter shall be fixed to the door frame, by means of hinges @ minimum 3 hinges per leaf. Maximum spacing of hinges being 600 mm with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

4.14.3.2 Medium Density Fibre Board Panel Shutter

MDF board panelled shutter shall in general conform to IS: 1003.

Materials

i) MDR-board

Medium density fibreboard shall conform to IS: 12406 Exterior grade (EGSB). It shall be dense, homogeneous and manufactured from agro based lingo-cellulosic fibres bonded with BWP type phenol formaldehyde synthetic resin conforming to IS:848. It shall be categorised as class I for Surfaces of very low flame spread as per IS-1642.

ii) Teakwood

Specifications of Teakwood shall be same as specified in Clause 4.12.2.1 of this section.

iii) Synthetic Enamel Paint and Primer

Synthetic Enamel paint conforming to IS:1932 of approved brand and manufacturer and of the required colour shall be used for the top coat and undercoat of shade to match the top coat as recommended by the manufacturer and specified under 'Painting'.

iv) Hinges Specification of hinges shall be same as specified in Clause 4.12.3.1 (iv)

Workmanship

Teakwood stiles, top rail and bottom rail of specified thickness and size shall be provided with suitable rebate. The MDF board shall be fitted in by means of teakwood moulded

beading of appropriate cross section. The beading shall be fixed by means of approved make neoprene based adhesive and nailing.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed. The surface of the teakwood stiles and rails shall be coated with 2 layers of approved quality polyurethane transparent coat with strainer to achieve the desired shade.

The shutter shall be fixed to the door frame be means of hinges @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm. with suitable sized screws. The shutter when fitted to the frame shall satisfy all operational aspects of door like smooth movement, proper closing against the door frame etc. The joints between stiles / rails and the panel shall be properly finished. Extra neoprene adhesive shall be removed and no gap between panel and stiles/rails shall be permitted. Any stain of paint on the panel surface shall be properly removed.

4.14.3.3 Glazed Wooden Door Shutter

Materials

i) Wood

Teakwood for various members like stiles, rails, etc. shall be as specified-in Clause 4.12.2.1 of this section.

ii) Glazing

Glass sheets for glazing shall be

a) 4 mm thick plain glass (wt. 7.2 kg/m^2) conforming IS:2835, or

b) 5.5 mm thick wired glass conforming to IS:5437 or

c) 6.3 mm thick laminated glass conforming to 1S:2553 as the case may be as per item description or

d) 5.5 mm thick toughened glass.

Glass sheets shall be free from flaws, scratches, cracks, bubbles etc.

iii) Hinges

Hinges shall be as specified in Clause 4.12.3.1 (iv)

Workmanship

Teakwood stiles and rails of size as specified in item description shall be cut accurately and planed smoothly to required dimensions. The stiles and rails shall be provided with rebates for fixing the glazing and shall be joined together to form the profile of the shutter. The joinery work shall be as approved by Employer. Only after such approval, the joints shall be coated with white lead, pressed and secured by hardwood pins of about 6 mm dia. All the four edges of the shutter shall be square. In case of double leaf doors, rebates shall be provided at the meeting of stiles. Rebates shall be splayed type and one third the thickness of the stiles.

The glass sheets for glazing shall be fixed by teak wood beading having mitred joints and shall be fixed by means of approved neoprene based adhesive and nailing, the spacing between the nails being no more than 300 mm. All wooden surfaces shall be coated with 2 coats of approved make polyurethane with strainer mixed to achieve desired shade.

The shutter shall be fixed to the door frame, by means of hinge @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm with suitable sized screws. The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

4.14.3.4 Flymesh Shutter for Door and Window

Specifications for Flymesh shutter shall be similar to specification for wooden glazed door, excepting following features:

i) In place of glass, net of galvanised MS wire-mesh of IS gauge designation 856 wire and dia 0.56 mm shall be fixed to the shutter frame with teakwood beading.

ii) Flymesh shutter shall be for both doors as well as windows.

iv) All wooden surfaces shall be painted with synthetic enamel paint of approved shade in two coats over a priming coat in place of French polishing.

4.14.3.5 Fire Resisting Door

Frame

Door frame with heat activated intumescent fire seal strips of size 12 mm x 4 mm (for smoke sealing) mounted in the groove in frame suitable for mounting 60/30 minutes fire rated shutters with one coat of anti-termite fire retardant primer.

Shutters / Panels

The shutters of the door shall be of approved make conforming to IS:3614 (Part I) shall be so designed so as to provide the specified fire resistance when tested as per IS:3614 (Part 2) and BS:2750 to suit the specified requirement and the manufacturer must produce certificates of the recognised laboratory to the approval of the Employer.

Asbestos free composite fire/smoke check shutters of 60 min, fire resistance rating, conforming to BS:476 part 22/IS:3614 Part 2) and shall comprise two non-combustible boards each 12 mm thick sand-witching 20 mm thick fire resistant insulation faced with 3 mm commercial ply veneering on both faces and seasoned teak wood lipping around the shutters with heat activated intumescent fire seal strips of size 12 mm x 4 mm mounted in the grooves in the shutters/panels on all sides except bottom.

Seal

A heat activated intumescent seal of approved quality and make conform to BS:476 (Part 8) shall be provided on all edges of doors to check the spread of smoke in case of fire.

Paint

The door frame and panel/shutter shall be treated with ready mixed silicate type fire retardant anti-terminal primer& paint of approved shade and manufacturer as per IS: 162 (BS:476-Part I)

4.14.3.6 Hold Fast

Hold fasts for use with wooden doors shall be made from mild steel flats not less than 5 mm thick in accordance to IS: 7196 and shall be galvanised. The shutter shall be supported by hinges as specified in Clause 4.12.3.1 (iv).

Hold fasts shall be fixed with the timber frame by steel screws only. The framed in masonry wall shall be fixed in cement concrete blocks as directed by Employer.

4.14.3.7 Iron Mongery

The Contractor shall submit a complete schedule of iron mongery for approval by the Employer. The schedule of iron mongery shall indicate the manufacturer's catalogue number, function, material, finish and other information required.

The Contractor shall supply and fix all iron mongery including cutting all necessary mortices rebates and the like.

a) Cargo Doors : All hardware by manufacturer. No lockset, padlocks shall be of the pin tubular type with solid or laminated brass case and steel hardened shackles.

b) Personnel Doors:

- Hardware assembly No. 1: Exterior doors double leaf
- 3 pairs butts : 12 cm x 12 cm
- 2 each flush bolts
- 1 each lockset
- 1 each stop

Hardware assembly No. 2 : Exterior doors single leaf

- 1½ pair butts : 12 cm x 12 cm
- 1 each lockset
- 1 each stop

Hardware assembly No. 3 : Interior doors (except toilets)

- 1½ pair butts : 12 cm x 12 cm
- 1 each lockset
- 1 each stop

Hardware assembly No. 4 : Toilet doors (0.70 x 2.00)

- 1 pair butts : 12 cm x 12 cm
- 1 each lockset
- 1 each stop

c) Windows / Ventilators

- Hardware assembly No. 5: Leaf opening windows
- Non-ferrous metal holders and 1 latch set
- 1 pair hinges
- Hardware assembly No. 6: Sliding Windows
- Roller
- 1 latch set
- 1 lockset

d) Operated door locks shall be cored and three keys for each lock and six master keys shall be furnished. Each key shall have a blank bow, one side for stamping purposes. Locks shall be keyed individually and in groups and master keyed in one series as directed by the Employer. The master keys shall be delivered directly to the Employer.

4.15 Roofing Treatment

4.15.1 General

This section of the specifications includes the requirements to provide, in place, all roofing treatments specified herein, or as required to provide a complete installation.

4.15.2 Material

The material shall consist of 2 pack clear / pigmented aliphatic polyurethane using polyurethane using polyether polyois (polyster or Castor Oil based polyois not acceptable), with iso-cynorate for rendering flame resistant characteristic. The 2 pack system, consisting of pigment and the solvent (Xylene/Toulene, no filler) shall be mixed in definite ratio by weight strictly as per approved manufacturer's specification, for preparing the coating for application. The coating shall have physical features like high resistance to impact, abrasion and cracking, superior tensile strength (80 kg/cm^2 after 4 weeks at ambient temp.),and perfectly smooth, dust free, glossy finish retained at least upto3 years. It should also be resistant to acid, alkalies and have a very low water absorption rate (0.5% max. at ambient temp. after 7 days).

The packs shall not be older than 9 months after the date of manufacture and packing

4.15.3 Workmanship

4.15.3.1 Preparation of Surface

The roof surface shall be thoroughly cleaned with a wire brush and all foreign matter etc. shall be removed. Well defined cracks on the surface shall be cut to 'V section, cleaned and filled up flush with a paste of 2 component polyurethane based crack filling compound and white cement in a ratio of 1:2.

4.15.3.2 Primer Coat

It shall consist of 2 pack polyurethane. Primer coat shall be mixed in the ratio as per manufacturer's specification. A single coat of this primer shall be applied by brush over the prepared bed as an adhesion coat. The primer shall be allowed to dry for a min. of 8 hrs. time before the successive finishing coats are applied Finishing coats:

4.15.3.3 Finishing Coats

The finishing coats shall consist of three successive pigmented sealing coats each of 2 pack polyurethane mixed in the ratio as per manufacturer's spec. Application shall be with brush, to a smooth and even finish. The overall dry film thickness shall be 450 microns or min. covering capacity shall be200gms/m^2 per coat.

Each coat shall be allowed to dry for min. 12 hours before applying next coat. Care shall be taken for quick application after mixing the 2 pack primer in view of short pot life of the mix and shall be fully consumed within the stipulated period as per manufacturer's spec (Max. 60 minutes at 30°C)

The finishing coating shall be continued up the parapets/walls for a min. of 150mm over the finished roof surface. It shall be continued into rain water pipes by at least 100mm.

4.15.3.4 Cement Screed

The final finishing coat when tacky shall be sprinkled with 300 micron layer of clean sand. Plain cement concrete (1:2:4) of 25mm min. thickness with 24 SWG chicken wire mesh shall be laid to slope in panels not exceeding 6 M^2 area per panel over this. The joints between panels shall be raked out neatly (after stipulated curing period) to a min. 6mm x 6mm v-

groove and filled up with an approved quality elastomeric compound sealant. Drain outlet shall be provided for all spouts/rain water pipes by suitable rounding, filling and sloping of PCC. At the junction of the roof and parapet or any other vertical surface, a fillet of 75mm radius shall be formed in cement mortar (1 cement: 4 coarse sand).

4.15.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

4.16 Plastering and Pointing

4.16.1 General

This section shall cover all plastering (internal/external) and painting works as specified herein. Before commencing the work sample of works shall be made in accordance with the specification and got approved by the Employer.

4.16.2 Materials

4.16.2.1 Cement

Cement shall conform to specifications under 'Material' unless otherwise specified.

4.16.2.2 Sand

Sand for plastering and pointing shall conform to IS 1542. Sand shall be hard, durable, dean and free from adherent coatings and organic matter and shall not contain any appreciable amount of silt, day balls or pellets. Sand shad not contain harmful impurities such as iron pyrites, coal particles, lignite, mica shale etc.

Sand whose grading falls outside the limits of IS 460 due to excess or deficiency of coarse or fine panicles shall be processed to comply with the standards. Fine sand shaft be obtained from river beds not affected by tidal water of the sea and shall be clean, sharp and free from excessive deleterious matter. The sand shall not contain more than 8 per cent of mud and silt as determined by field test with a measuring cylinder.

4.16.2.3 Water

Water for plastering and pointing shall conform to specifications under 'Material'.

4.16.2.4 Cement Mortar

Preparation of cement mortar shall conform to specifications under 'Brick Masonry' unless otherwise mentioned.

4.16.3 Cement Mortar with Waterproofing Compound

Waterproof compound shall conform to IS 2645 of approved make. The compound shall be well mixed with dry cement in the proportion of 3% by weight or as recommended by manufacturer. Further procedures for preparation of cement mortar shall be as per Clause 4.14.2.4 above.

4.16.4 Workmanship

4.16.4.1 Preparation of Background Surface

The surface shall be cleaned off all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing. Smooth surfaces shall be roughened by wire brushing or hacking for non-hard and hard surfaces respectively. Projections on surfaces shall be trimmed wherever necessary to get even surfaces. In case

of brick/stone masonry, raking of joints shall be carried out wherever necessary. The masonry shall be allowed to dry out for sufficient period before carrying out the plasterwork. The masonry shall not be soaked but only damped evenly thereafter before applying the plaster.

In case of concrete work, projecting burrs of mortar formed due to the gaps of joints in shuttering shall be removed. Such surface shall be scrubbed clean with wire brushes. The surface shall be pock marked with a pointed tool at spacing of not more than 50 mm centers, the pocks being made not less than 3 mm deep to ensure a proper key for the plaster. The surface shall be washed off and cleaned of all oil, grease etc. and well wetted before the plaster is applied.

4.16.4.2 Sequence of Operation

For external plaster, the plastering operations shall be started from the top floor and carried downwards. For internal plaster, the plastering may be started wherever the building frame, roofing, and brickwork are ready.

The surfaces to be plastered, shall first be prepared as described in Preparation of background surface in Clause 4.14.4.1 above. The first underlay shall then be applied to ceilings. After the ceiling plaster to complete and scaffolding for the same removed, plastering on wall shall be started.

After a suitable time interval as detailed under various types of plaster in subsequent paras, depending upon the type of mortar, the secondary layers if required shall be applied. After a further suitable time interval as detailed under various type of plaster in subsequent paras, the finishing coat shall be applied first to the ceiling and then to the walls.

Plastering of cornices, decorative features, etc., shall be completed before the finishing coat is applied. Unless otherwise specified Corners and edges shall be rounded off to a radius of 25mm, such rounding off shall be completed along with the finishing coat to prevent any joint marks showing out later.

4.16.4.3 Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, Clause no. 4.8.6 of Specification.

4.16.4.4 Damage Rectification

Any cracks, damages, any part of work which sound hollow when tapped or found damaged or defective otherwise shall be cut out in rectangular shape and redone as directed by Employer.

4.16.5 Plain Cement Plaster

4.16.5.1 Preparation of Mortars

The mortars of specified mix shall be used as per the specifications of "Cement Mortar' described in Clause 4.14.2.4 above.

4.16.5.2 Application of Plaster

One Layer Plaster Work

To ensure even, specified thickness, plaster of 150 mm x 150 mm shall be first applied horizontally and vertically at not more than 2 meter interval over the entire surface to serve as gauges. The surface of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be brought to true surface by working with a wooden straight edge

reaching across the gauges with small upward and sideways movements at a time. Finally the surface shall be finished off true with a trowel or wooden float to obtain a smooth texture. Excessive trowelling or overworking the float shall be avoided. All corners, arises, angles and junctions shall be truly vertical/horizontal and shall be carefully finished. Rounding or chamfering of corners, arises, junctions etc., shall be carried out with proper templates to the size required.

In suspending the work, the plaster shall be left, cut clean to line, both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped clean and wetted before plastering the adjoining area. Plastering work shall be closed on the border of the wall and nearer than 150 mm to any corners or arises and shall not be closed on the body of the features such as plaster bands, cornices nor at the comers or arises.

Two Layer Plaster Work

- First or under layer

The first or underlay of the specified thickness shall be applied as described above in Clause 4.14.5.2. Before the first coat hardens, surface of it shall be beaten up by edges of wooden tapers and close dents shall be made on the surface. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

- Second or finishing layer

The second layer shall be complete to the specified thickness in the same manner as for first layer.

4.16.5.3 Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of 7 days. During this period the plaster shall be suitably protected from all damages by such means as approved by the Employer. The date of execution of plastering shall be marked on the plastering to ensure the proper duration of curing.

4.16.6 Sand Face Plaster

4.16.6.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.14.2.4.

Application of Plaster

Sand face plaster shall consist of 13 mm thick (1 cement: 4 coarse sand by vol) underlayer and 7 mm thick (1 cement: 2 coarse sand by volume) top layer. Application of plaster shall be as described in 'two coat plaster work' in Clause 4.14.5.2 above. The surface of the sand face plaster shall be finished rough with sponge or as directed by the Employer.

Curing

Curing shall be as described above in Clause 4.14.5.3.

4.16.7 Exposed Aggregate Finish Plaster

4.16.7.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.14.2.4. White and coloured marble chips shall be of 6 mm to

12mm size out of Makrana/Ambaji, grade 1 or Dongri Chittor Brown/Rajnagar/Abu green grade-1 quality. Marble dust shall be obtained from crushing hard marble stone. It shall not be less than 1.0.

4.16.7.2 Application of Plaster

Exposed aggregate finish plaster shall consist of 12mm thick plain cement plaster underlayer (1cement: 4 coarse sand by volume) finished rough and 20 mm thick top layer. Underlayer shall be applied in accordance with "One layer plaster work" described above in Clause 4.14.5.2.

Top layer shall be 20 mm thick admixture of white cement and grey cement (mix. ratio 1:1 by volume) mixed with while/coloured marble chips/pebbles of 6mm to 12mm nominal size as per item description. Mix ratio shall be 1cement: 1 marble chips/pebbles by volume Marble dust @ 15% by volume shall be added to the admixture. The pebbles to be used shall be well washed and drained. The admixture shall be thrown wet on to the under layer while it is still plastic using strong whipping motion at right angles to the lace of the wall. One coat of neat cement slurry @ 2.75 kg cement per square metre of area shall be applied on to the underlayer to receive the top layer The whole plastering laid in panels with 12mm x 20mm grooves in between formed by holding removable wooden battons of 12mmx x 25mm size over the under layer.

The top layer admixture pressed flat over the underlayer filling uncovered parts by hand, so that the finished surface represents a homogeneous surface. Loose mortar etc. on the top surface shall be cleaned/removed by brushing/washing /spraying with water jet after initial setting of mortar.

4.16.7.3 Curing

Curing shall be as described above in Clause No. 4.14.5.3.

4.16.8 Pointing

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

4.16.8.1 Preparation of Base Surface

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of the brick shall be less than 20 mm.

Mortar

Mortar shall be in accordance with the specifications of cement mortar described above in Clause 4.14.2.4.

Application of Mortar and Finishing

The mortar shall be pressed into the raked out joints with a pointing trowel according to the type of pointing specified. The mortar shall be spread over the corner edges or surfaces of the masonry. The pointing shall then be finished with the pointed tool.

The superfluous mortar shall be cut off from the edges.

Flush Pointing

The mortar shall be pressed into joints and shall be finished off flush and leveled. The edges shall be neatly trimmed with trowel and straight edges.

Cut or Weather Struck Pointing

The mortar shall first be pressed into joints. The top of the horizontal joints shall then be neatly pressed back by about 15 mm with the pointing tool so that the joint is sloping from top to bottom. The vertical joint shall also be similarly pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles in case of brick & coursed rubble masonry.

Raised and Cut Pointing

This type of pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm and width 10 mm more as directed. The pointing shall be finished to a smooth but hard surface.

Curing

Curing shall be as described above in Clause 4.14.5.3

4.17 Floor Finishing

4.17.1 General

This section shall cover all flooring and wall tiling work and specified for different terminal buildings as given below.

S. No.	Building	Type of Flooring
1.	Terminal Administration building	Glazed Tile/Kota Stone/Marble stone/PVC Flooring
2	Worker's Amenity building	Cement concrete / Terrazzo /Kota stone Flooring
3	Weigh Bridge control cabin & security office building with toilet	Cement concrete / Terrazzo/ Glazed Tile /Kota stone Flooring
4	Electrical Substation	Cement concrete / Kota stone Flooring
5	Security Office	Cement concrete / Terrazzo /Kota stone Flooring

No work under this section shall be started until specifically allowed by the Employer and until all other major works such as plastering, embedding of conduits and pipes channels, window fixing etc. have been completed. Samples of basic materials and work of adequate size representing the nature of variation including quality, size, texture after finishing to be used in the flooring work shall be prepared for all work and got approved by the Employer sufficiently prior to ordering. The approved samples shall be retained upto the end of the project. The works shall be got done by skilled and specialised workmen experienced in the respective trade of work.

Reference shall be made to the following Indian Standards:

IS: 4971 Recommendations for selection of Industrial floor finishes

IS: 2114 Code of practice for laying insitu terrazzo floor finish.

IS: 1237 Specification for Cement concrete flooring tiles

IS: 777 Specification for glazed earthenware wall tiles

IS: 2571 Code of practice for laying in situ cement concrete flooring

IS: 4631 Code of practice for laying of epoxy resin floor toppings.

IS: 3462 Code of practice for unbaked flexible PVC flooring

IS: 5318 Code of practice for laying of flexible PVC sheet and tile flooring

IS : 3461	Spec for PVC asbestos floor tiles
IS: 1443	Code of practice for laying in situ grasnolithic concrete floor topping
IS: 5491	Code of practice for laying in situ granolithic concrete floor topping
IS: 4441	Code of practice for use of silicate type Chemical resistant mortars
IS : 4443	Code of practice for use of resin type chemical resistant mortar
IS : 1196	Code of practice for laying Bitumen Mastic flooring

4.17.2 Cement Concrete Flooring General

4.17.2.1 General

Cement concrete flooring shall in general conform to IS 2571. Cement conrete flooring shall consist of a sub base (laid on the compacted earth or sand fill In case of ground floor only) a base course laid on the sub-base and then finishing layer of floor finishing. Where the cement concrete flooring is to be laid directly on the RCC slab, the surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg. of cement per sq.m. shall be applied, so as to get good bond between RCC slab and concrete floor. In case of ground floor, the filled and compacted bed on which the sub-base is to be laid, shall beas per specifications.

The bed for flooring shall be prepared either level or sloped as instructed by Employer.

4.17.2.2 Workmanship

Sub-base

The sub-base which shall be laid on the prepared bed shall be of specified thickness as per specifications. The sub-base shall be of cement concrete. In case of upper floors, the structural RCC slab shall be treated as sub-base.

Base Course

Base course shall be of cement concrete of specified mix and of specified thickness/item descriptions and snail generally conform to specification (Plain and Reinforced Cement Concrete).

The floor space on which base course is to be laid shall be divided into square/ rectangular or as per designed panels to prevent cracks in the floor finish. No dimension of the panels shall exceed 2m and length of the panel shall not exceed 1.5 times its breadth. Base course shall be laid on alternate panels. The borders of the panels shall have mitred joints at the comers ot the room and intermediate joints shall be in straight line with panel joints.

The panels shall be bound by MS strips/PVC strips etc. These shall be fixed in position with their top at proper level, giving stope wherever required. The flooring shall butt against masonry of wall which shall not be plastered.

When the base course is to be laid on hardened base, the sub-base shall be roughened by steel wire brushing and cleaned. Before laying the base course, neat cement slurry shall be brushed into the prepared surface.

Cement concrete shall be placed in position and beaten with trowel and finished smooth. Beating shall cease as soon as surface is found covered with cream of mortar. Necessary slope shall be provided.

Floor Finishing

Finishing of the surface shall follow immediately after the completion of base course. The base course shall be free of excessive moisture before starting the floor finishing. Use of dry cement, cement sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall not be permitted.

While the concrete is still green, cement @ 2.75 kg per square meter of floor area shall be mixed with water to form a thick slurry and spread over the surface. It shall be pressed twice by means of iron ftoats, once when the slurry is applied and second time when the cement starts setting. The junction of floor with wall plaster, cladding, skirting shall be rounded off uniformly upto a radius of 25mm unless otherwise mentioned.

Curing

Each finished portion of floor, on completion shallbe kept wet with ponding for a minimum period of 7 days.

4.17.3 Cement Concrete Granolithic Flooring

4.17.3.1 General

Cement concrete granolithic flooring shall consist of a sub-base, a base course, finishing layer of floor finish. Workmanship, shall in general be same as for cement concrete flooring, unless otherwise mentioned.

4.17.3.2 Workmanship

Workmanship shall in general conform to IS : 5491.

Sub-base

Refer Clause 4.15.2.2 above.

Base Course (under-layer)

Refer Clause 4.15.2.2 above.

Wearing Top Layer

The top layers shall be laid over first layer within 15 minutes of laying the first layer. The cement and aggregates for the top layer shall be mixed dry. After mixing, sufficient quantity of sand and water shall be added to make the mix plastic but not flowing. The top and bottom layer shall firmly grip together.

Floor Finishing

Refer Clause 4.15.2.2 above.

Curing

Refer Clause 4.15.2.2 above.

4.17.4 Heavy Duty Flooring

4.17.4.1 General

Heavy duty Flooring in workshop shall consist of a sub-base, a base course and a finishing layer of floor finish.

4.17.4.2 Workmanship

Sub-base

Refer Clause 4.15.2.2 above.

Base Course

Base course shall consist of one layer of cement concrete of speficied mix and thickness laid on sub-base in panels in accordance with Clause 4.15.2.2 above.

Floor Finish

Finishing layer shal be of cement, hardener and stone aggregate mix of specified proportion and thickness laid over the base course. Unless otherwise mentioned, one part of approved quality hardner and four parts ofcement by weight shall be mixed dry. This dry mixture shall be mixed with stone grit of 6mm and down size in the ratio of 1 hardener and cement mixture : 2 stone grit by volume. Just enough water shall then be added to the mix.

The mixture so obtained shall then be laid on the base course within 2 to 4hours of later's laying It shall be firmly pressed into bottom concrete so as to have a good bond with it. After the starting of initial setting, the surface shall be finished smooth and true with steel floats.

4.17.5 Precast Hydraulically Pressed Cement Tiles Flooring

4.17.5.1 Materials

Cement Concrete Tiles

Cement conrete tiles shall conform to IS 1237 and shall be of approved shade, with 10 mm down size stone aggregates and using a 1:6 or as directed mixture of white and ordinary cement and shall be of specified thickness and apprd. shade.

Pigments

Pigments to be admixed with mortar or for grouting shall conform to Table 1 of IS 2114.

Cement Mortar

Cement mortar shall be of specified mix and thickness and shall be in accordance with Clause 4.15.2.1 of the specification under ‘Materials’.

Workmanship

Workmanship shall in general conform to IS : 1443. The base on which tiles are to be laid shall be cleaned of all dust, dirt and property wetted without allowing water pools. Cement mortar of specified thickness shall then be spread over the base for two rows of tiles and 3-5 metres in length. The mortar shall be laid in slope as per requirements and thickness of mortar shall not be less than 10mm at any place. The top of the mortar shall not be less than 10mm at any place. The top of the mortar shall be kept rough so that cement slurry can be absorbed. Laying shall be from centre & proceed outwards in the two directions at 90°. Cut tiles of uniform sizes shall be laid along periphery, if necessary. Neat cement slurry @ 4.4 kg. of cement per Sq.M. shall be spread over the mortar bed laying 20 tites at a time. The tiles shall then be fixed in this grout one after the other, each tile being gently tapped and properly bedded in line and level. The joints shall not exceed 1.5mm in width. After the day's work, the excess cement slurry on top and the joints shall be cleaned with broom stick and washed before the slurry sets hard. Next day, the joints shall be filled with the cement grout of the same shade as the matrix of the tile.

Tiles along the periphery shall be continued by average 12 mm under the wall plaster, skirting or dado.

Curing

The flooring shall be cured for 7 days by keeping it wet with ponding. Heavy traffic on the flooring shall be permitted only after 14 days.

Grinding and Polishing

Grinding shall be commenced after 14 days when the tiles and the joints are property set. Grinding shall be done by machines except for skirting and small areas. First grinding shall be done with carborundum stones of 48 to 60 grade grit fitted in the machine. Water shall be properly used during grinding. When the chips show up and the floor has been uniformly rubbed, it shall be cleaned with water baring all pin holes. It shall then be coverred with a thin coat of grey/white cement mixed with pigments to match with colour of the flooring. This grout shall be kept moist for a week. Thereafter the second grinding shall be started with carborundum stone of 120 grit. Grinding and curing shall follow again. Final grinding shall be with carborundum of grade 220 to 350 grit using water in abundance. The floor shall be washed clean with water, oxalic add powder shall then be dusted at 33 gms/sq. m. on the surface rubbed with machine fitted hessian bobs or rubbed hard with woolen rags. The floor shall then be washed clean and dried with a soft cloth or linen. If any tile is disturbed or damaged, it shall be refitted or replaced proper jointed and polished.

4.17.6 Cement Plaster Skirting

4.17.6.1 Material

Cement plaster skirting shall be laid with cement mortar as per Clause 4.8.2.1 specification under Brick Masonry Work and shall be of specified proportion and thickness.

4.17.6.2 Workmanship

The surface on which the skirting is to be applied shall be prepared and skirting of specified thickness shall be laid in accordance with Clause 4.14.4.1, specification under Plastering & Pointing. The junction between flooring and wall shall be rounded off to a radius of 25mm if not otherwise mentioned.

While the mortar is still green, cement @ 2.75kg per square metre shall be mixed with water to form a thick slurry and applied over the mortar. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when the cement starts setting.

4.17.7 Cast-In-Situ Terrazzo Flooring

4.17.7.1 Material

Cement Concrete

Specification of cement concrete shall be same as in Specification under Plain and Reinforced Concrete.

Aggregates for Terrazzo Topping

The aggregate to be used in topping shall be marble chips of plain white Pink, Makrana. Grade Baroda green etc. as specrfied which shall be of 10mm nominal size. Marble powder to be used in terrazzo topping shall pass through IS Sieve Terazzo. Marble chips shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. All proportions of Materials used should be as directed by the Employer described in the item.

Pigment

Pigments to be used in Terrazzo shall be of permanent colour and shall conform to IS-2114, Table-1.

4.17.7.2 Workmanship

Workmanship shall in general conform to IS -2114. Terrazzo flooring shall be of specified thickness and shall be laid in two layers and in panels. Under layer or base course shall be of cement concrete laid over sub-base and top layer shall be of terrazzo floor finish.

Top layer shall consist of mix of white cement, marble powder, marble chips, water and pigments. Cement and marble powder mix proportion shall be 3 : 1 by weight. Cement, marble powder mix shall be mixed with marble chips in the proportion of 4:7 by volume. Quality and shade of chips and powder shall be as specified with a view to avoid variation in colour. Sufficient quantity of while cement shall be added in the cement mix to obtain the desired shade. Mixing shall be done in a trough or tub and complete quantities of white cement and pigment for a particular unit of job shall be dry mixed with aggregates. Water shall be added in small quantities to this dry mix to get a proper consistency. The mix shall be plastic but not so wet to flow. The mix shall be used within 30 minutes of its preparation.

The base course/under layer shall be divided in panels with dividing strips (G.I./Aluminium Alloy /PVC) upto the finished surface levels. The sub-base shall be cleaned of all dust, dirt or any loose material. It shall then be wetted with water, mopped and smeared with neat cement slurry .

Terrazzo topping shall be laid while the underlayer is still plastic but has hardened enough which is normally achieved between 18-24 hours after laying the underiayer. A cement slurry pigmented with the same colour as the topping be brushed on the surface immediately before laying the topping. The terrazzo mix shall be laid to a uniform thickness and be compacted throughly by tamping or rolling and trowelled and brought true to required level by a straight edge and steel floats so that the maximum amount of marble chips come up and spreaded uniformly over the surface and no part of the surface is left without the chips.

Curing

The surface shall be left dry for air curing for a period of 12-18 hours. Thereafter water shall be allowed to stand overnight in pools for a period of minimum four days.

Grinding and Polishing

Grinding and polishing shall be done wtth machines and shall start after 7 days of laying. First griinding shall be done with carborundum stone of 60 grit size. The surface shall then be washed clean and grouted with a grout of cement and/of colouring matter in same mix and proportion as the topping in order to fill any pin notes that appear. It shall then be allowed to dry for 24 hours and wet cured in the same manner as mentioned above in Clause 4.15.7.2. The second grinding shall be done with carborundum stone of 80 grit size. The surface shall then be prepared as after first grinding .The third grinding shall be done wtth carborundum stone of 120 to 150 grit size. The surface shall then be prepared againas after first grinding.

The fourth griniding shall be done with carborundum stone of 320 to 400 grit size. The surface shall then be washed clean and rubbed hard with felt and slightty moistened oxalic acid powder @ 33 gms per square metre of floor surface. After the finishing works are over, the surface shall be washed with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt on hessian bobs shall then be run over it until the floor shines.

In case of polishing, wax polish shall be applied on the surface with the help of soft linen over a clean and dry surface. Then the polishing machine fitted with bobs shall be run over it. Clean saw dust shall be spread over the floor surface and polishing machine again operated to remove excess wax.

4.17.8 Cast-In-Situ Terrazzo Skirting and Dados

4.17.8.1 Material

Refer Clause 4.15.7.1 above.

4.17.8.2 Workmanship

Cast-in-situ Terrazzo in skirting and dado shall be of specified thickness and of same shadeas that of the flooring.

Underlayer for terrazzo on vertical surfaces shall be of stiff cement mortar 1:3 (1 cement: 3 coarse sand by volume) finished rough so as to give a good bond to the topping. Terrazzo topping shall be average 12mm thick and underlayer shall be 13 mm thick. Terrazzo topping shall be laid on the underlayer in accordance with Clause 4.15.7.2 above. Other details shall be same as for flooring excepting grinding which shall be manual.

4.17.9 Precast Hydraulically Pressed Terrazzo Tile Flooring

4.17.9.1 Materials

Terrazzo Tiles

Terrazzo tiles shall be of specified thickness and shade and shall generally conform in all respects to IS-1237.

Pigment

Refer Clause 4.15.7.1 above.

Cement Mortar

Refer Clause 4.15.5.1 above.

4.17.9.2 Workmanship

Refer Clause 4.15.8.2 above.

Curing

Refer Clause 4.15.7.2 above.

Grinding and Polishing

Refer Clause 4.15.7.2 above.

4.17.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado

4.17.10.1 Material

Terrazzo Tiles

Same as in Clause 4.15.9.1 above. The average thickness of tiles shall however be 20mm.

Pigments

Same as in Clause 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.17.10.2 Workmanship

In case of brick masonry wall, the joints shall be raked out to a depth of at teast 15mm white the masonry is being laid. In case of concrete work, the surface shall be hauled and roughened with wire brushes.

The wall surface shall be uniformly and evenly covered with 12mm thick backing of cement mortar 1:3 (1 cement: 3 coarse shand by volume). Before hardening of the cushioning mortar, back of each tile shall be covered with a neat layer of cement slurry @ 4.4.kg of cement per Sq.M. and edges with white cement with or without pigment to match the shade of tiles and the tiles then shall be pressed on the backing and tapped.

The tiles shall be corrected to proper planes with joints truly vertical in required pattern and butt jointed. The fixing shall be done from bottom upward. The top of skirting and dado shall be truly horizontal.

Curing, Grinding and Polishing

Same as in Clause 4.15.7.2 above.

4.17.11 Glazed Tiles Work

4.17.11.1 Material

Tiles

Glazed tiles shall conform to 1S: 777 and shall be of specified shade, size and of approved manufacturer.

Pigments

Same as in Clause 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.17.11.2 Workmanship

The tiles shall be laid over a coating of specified adhesrve (as per approved manufacturer's specification) laid on base floor/ wall plaster. The joints of the tites shall be flush pointed with cement paste (white cement and pigment conforming to IS-2114, Table-1) matching the shade of colours.

Curing

Same as in Clause 4.15.7.2 above.

4.17.12 Glazed Tiles in Risers of Steps, Skirting and Dado

4.17.12.1 Materials

Same as in Clause 4.15.11.1 above.

4.17.12.2 Workmanship

Same as in Clause 4.15.11.2 above.

Curing

Same as in Clause 4.15.7.2 above.

4.17.13 Kota Stone Flooring

4.17.13.1 Materials

The slabs shall be of selected quality and shade, hard, sound, dense, homogenous in texture, free from cracks, decay .weathering and flakes. These shall be machine cut to the requisite size and thickness and chisel dressed. The slabs shall have the top (exposed) face polished before being brought to site. Before starting the work, the Contractor shall get the samples of slabs approved by the Employer.

4.17.13.2 Workmanship

Each slab shall be machine cut to the required size and shape and fine chisel dressedat all edges to full depth and machine rubbed to a smooth surface finish. All angles and edges of the slabs shall be true square and free from chippings carving a plane and smooth surface.

Preparation of Surface

Cement mortar 1:6 (1 cement: 6 coarse sand by volume) of specified thickness shall be laid over the base after making it rough and cleaning thoroughly. The mortar shall be laid for facing one slab at a time.

Laying

The slab shall be washed clean before laying. It shall be laid over cement mortar bedding on top, pressed, lapped gentry to bring it in level. It shall be then lifted and laid aside. Top surface of the mortar then shall be corrected by adding fresh mortar at hollows and depressions. The mortar then shall be allowed to harden and cement slurry of honey like consistency @ 4.4 kg of cement per Sqm shall be spread over the mortar. The edges of the slabs shall be buttered with white cement with or without pigment grout to match the shade of the slabs. The slabs shall then be gently placed in position and tapped with wooden mallets till it is property bedded in level. The joints shall be as fine as possible. Surplus cement on the surface of the slab shall be removed. The slabs in flooring shall continue for not less than 10 mm under the plaster/ skirting. The finished surface shall be true to levels and slopes as instructed by the Employer.

The slabs shall be laid in patterns and size shall not be less than 310mm X310mm. Cut uniform size may be used along periphery as required.

Curing

The floor shall be cured for a minimum period of 7 days by wetting.

Polishing and Finishing

Unevenness at the meeting edges of slabs shall be removed by fine chiseling. Polishing etc. shall be done in accordance with Clause 4.15.7.2 mentioned above except that cement slurry shall not be applied on the surface before each polishing.

4.17.14 Kota Stone in Risers of Steps, Skirting and Dado

4.17.14.1 Materials

Same as in Clause 4.15.13.1 above.

4.17.14.2 Workmanship

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Refer Clause 4.15.7.2 above.

4.17.15 Marble Stone Flooring

4.17.15.1 Materials

Marble Slabs

The slabs shall be of the kind of marble specified in the item. The marble from which the slabs are made shall be of selected quality, hard, sound, dense, homogenous in texture, free from cracks, decay, weathering and flakes. The sample of Marble stone slabs shall be got approved from the Employer. The slabs shall he machine cut to the requisite dimensions.

Pigments

Same as in Clause 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.17.15.2 Workmanship

Same as in Clause 4.15.13.2 above.

Curing

Same as in Clause 4.15.13.2 above.

Polishing and Finishing

Same as in Clause 4.15.7.2 above.

4.17.16 Marble Stone in Risers of Steps and Skirting

4.17.16.1 Materials

Same as in Clause 4.15.15.1 above.

4.17.16.2 Workmanship

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Same as in Clause 4.15.7.2 above.

4.17.17 P.V.C. Flooring

4.17.17.1 Materials

P.V.C. Roll/ Tiles

P.V.C. Roll shall be of homogenous, un-backed, flexible type of approved, colour and pattern, conforming to IS - 3462/3461 and of specified thickness.

Antistatic PVC Roll

Antistatic P.V.C. roll shall conform to B.S.2050. Table-2 in addition to IS-3462

Adhesive

Adhesive shall be neoprene based rubber adhesive of approved make.

4.17.17.2 Workmanship

Preparation of Base

The preparation of sub-base and base course shall be same as in Clause 4.15.2.2.

Finishing Layer

The base course shall be thoroughly dried and cleaned well before the laying of P.V.C. rolls/ tiles. P.V.C. rolls/tiles shall be brought to the temperature of the area in which it is to be laid and stacked suitably near the site for a period of about 24 hours.

The layout of P.V.C. flooring shall first be marked with guidelines on the base course to required pattern without adhesive. The adhesive then shall be applied by spatula to the base floor and back of the PVC roll/tile. PVC rolls shall be placed in position from one end onwards slowly without creation on any air pockets between the roll and the base course. PVC rolls/ tiles shaft be placed only when the adhesive is set sufficiently for laying. When set sufficiently for laying, the adhesive will be sticky to the touch but shall not mark the fingers. After placing, the roll shall be pressed suitably with a wooden roller weighing about 5 kg. The joint between adjacent rolls shall be thin hairline type. For PVC tiles laying shall start from centre and proceed outwards in the two right angle directions till the periphery of the room/area is reached. Fractional tiles of uniform cut sizes may be laid only along the peripheral border if so required owing to size of the room/area.

PVC rolls in flooring shall be continued for 100mm high skirting without any joints and with 50mm radius rounded corner at the junction of skirting and flooring. Any excess adhesive squeezing out of the surface shall be wiped off immediately with a wet cloth. In case of such excess adhesive becoming hard, it shall be removed with a solution of one part of commercial Butyle Acetate and three parts of turpentine oil or any other solution as advised by the manufacturer of the roll.

After a minimum period of 24 hours after laying the rolls/ tiles, the finished floor shall be cleaned with a wet cloth soaked in warm soap solution of 2 spoons of soft soap powder in 5 liters of warm water or detergent as per approved manufacturer's specifications.

4.17.18 Acid Resistant Tiles in Floors

4.17.18.1 Material

The tiles shall be vitrified ceramic tiles and shall be homogeneous. They shall have the following properties:

S.No. Characteristics	Value Required	Norms
1) Water Absorptions	+ 0.5%	ASTM C 373
2) Scratch Resistance	> 6	ASTM C 373
3) Chemical Resistance	Unaffected	ASTM C 650
4) Abrasion Resistance (Hardness)	> 100	ASTM C 501
5) Breaking Strength	1400 kg/sq.cm	ASTM C 648
6) Density	> 2.0 Gm/CC	

4.17.18.2 Workmanship

The base course shall be in accordance with Clause 4.15.2.2 and background surface shall be prepared as per Clause 4.15.13.2 and IS: 4443.

Tiles shall be fixed on the prepared surface over a bitumen priming layer, bitumen mastic layer and resin type chemical resistant mortar. The bitumen shall conform to IS-702 and laying of bitumen mastic shall confirm to IS-1196. Joints shall be allowed to set for 24 hours. The floor shall then be washed as per manufacturer's specifications to totally remove all marks from tile surface.

4.17.19 Epoxy Floor Coating

4.17.19.1 General

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

4.17.19.2 Materials

Screed

The screed shall be a solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre-weighed units ready for on-site mixing and application.

Finishing Coat

An epoxy resin sealing coat of specified thickness shall form the topping coat.

4.17.19.3 Workmanship

Preparation of Surface

The surface shall be sound, clean and dry In order to achieve maximum adhesion with the primer coating.

Laying

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers' specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a slightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours

4.18 Painting

4.18.1 General

This section of specifications includes all requirements necessary for the white washing, colour washing, distempering, painting, and polishing of all surfaces specified herein or as may be necessary for the completion of the areas intended. When shop priming, specified under other sections of these specifications is provided, this may serve as the first of the number of coats herein specified.

All materials required for the execution of painting work shall be obtained direct from approved manufacturers and shall be brought to the site in makers drums, kegs etc. with seals unbroken. If in case of ready mixed paints, thinning if necessary, the brand of thinner shall be as per recommendations of the manufacturer.

Paint shall be applied by brushing or spraying. The brushing operations are to be adjusted to the spreading capacity advised by the manufacturer. During painting, every time after the paint has been worked out of the brush bristles, the bristles shall be opened up by striking the brush suitably.

Spray machine used may be of high pressure type or low pressure depending on the nature and location of work. After work, the brushes shall be completely cleaned off paint and shall be hung in a thinner if intended to be used afterwards. The spray guns shall be cleaned thoroughly after every break in work. The paint containers, when not used shall be kept close and free from air.

After the finishing of work, the adjacent surfaces not intended to be washed/ distempered/painted/polished, shall be thoroughly cleaned of all paint patches and shall be finished in accordance with surface finishing of such surfaces.

Indian Standards

IS 712 Specification for building limes.

IS 55 Specification for Ultramarine blue for paints.

IS 63 Specification for whiting for paint and putty.

IS 427 Distemper (dry), colouras required.

IS 428 Distemper (Oil Bound), colour as required.

IS 5410 Cement paint, colour as required.

IS 384 Brushes, paints and varnishes, flat

IS 486 Brushes, sash, tool, for paints and varnishes.

IS 110 Ready mixed paint, brushing, grey filler enamels for use over primers.

IS 426 Paste filter for colour coats.

IS 345 Wood filler, transparent liquid.

IS 3585 Ready mixed paint, aluminium brushing priming water resistant for wood work

4.18.2 White Washing

White washing in general shall confirm to IS 6278.

4.18.2.1 Workmanship

Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

Preparation of Surfaces

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied. Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of white wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq.m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS:2395.

Preparation of White Wash

The fat lime confirming to IS 712 shall be slaked at site and shall be mixed and stirred with about 5 litres of water for 1 kg. of unslaked lime to make thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 4 kg of gum dissolved m hot water shall be added to each cubic metre of lime cream. Approved quality uttermarine blue conforming to IS 55 @ 3 grams per kg of lime shall also be added to the solution. The whole solution shall be stirred thoroughly before use.

Application

White wash shall be applied with 'Moonj' brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke. Similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied. The white washing on ceiling should be done prior to that on walls.

Protective Measures

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

4.18.3 Colour Washing

4.18.3.1 Workmanship

Scaffolding

Scaffolding shall be as per Clause 4.16.2.1 above.

Preparation of Surface

Refer Clause 4.16.2.1 above.

Preparation of Colour Wash

Sufficient quantity of colour wash enough for the complete job shall be prepared in one operation to avoid any difference in colour. The basic white wash solution shall be prepared in accordance with above Clause 4.16.2.1. Mineral colours of approved shade and quality not affected by lime shall be added to the white wash solution in proportions as directed by Employer. Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution.

Application of Colour Wash

Application of colour wash shall be in accordance with above Clause 4.16.2.1.

Protective Measure

Same as in Clause 4.16.2.1 above.

4.18.4 Dry Distempering

4.18.4.1 Workmanship

Scaffolding

Same as m Clause 4.16.2.1 above.

Preparation of Surface

The surface shall be thoroughly brushed free from dust, dirt, grease, mortar droppings, other foreign matter and shall be made smooth by sand papering. In case of distempering over existing distempered surface, the existing distempering shall be scrapped by steel scrappers leaving a clean surface.

All nails shall be removed. Pitting in plaster shall be made good with plaster of paris mixed with dry distemper of colour to be used. The surface then shall be rubbed down again with a fine grade sand paper and made smooth. A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is allowed. The surface affected by moss, fungus, algae efflorescence shall be treated in accordance with IS 2395.

Priming Coat

A priming coat of whiting conforming to IS 63 shall be applied over the prepared surface. The priming coat shall be prepared by mixing 2.5 kg of whiting and one litre of glue solution (prepared by mixing 250 gm. glue conforming to IS 852 with boiling water) together and placing it in a covered vessel with enough water to cover the mixture which shall be left to cool until it becomes a jelly.

The application of priming coat shall be in accordance with above Clause 4.16.2.1.

Preparation of Distemper

The dry distemper of approved shade and quality conforming to IS 427 shall be stirred slowly in clean warm water using 0.6 litres of water per kg of distemper. It shall be allowed to settle for at least 30 minutes before applying. The mixture shall be well stirred before and during use to maintain an even consistency.

Application of Distemper

After the priming coat has dried for atleast 48 hours, the surface shaft be lightly sand papered and dusted off avoiding rubbing off of the priming coat

Prepared distemper shall then be applied in minimum two coats with proper distemper brushes in horizontal strokes immediately followed by vertical ones which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform without patches, marks, distemper drops etc.

The application of a coat in each room shall be finished in one operation. After each days work, brushes shall be thoroughly washed in hot water and hung down to dry.

Protective Measure

Same as in Clause 4.16.2.1 above.

4.18.5 Oil Bound Distempering

4.18.5.1 Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Preparation of surface shall in general be in accordance with above Clause 4.16.4.1 except that any unevenness shall be made good by applying putty made of plaster of paris mixed with water including filling up the undulation and then sand papering the same after it is dry.

Primer Coat

The primer coat shall be alkali resistant primer or distemper primer and shall be of the same manufacture as oil bound distemper.

If the wall surface plaster has not dried completely, alkali resistant primer otherwise distemper primer shall be applied. The mixture of alkali resistant primer shall be prepared as per approved manufacturer's instructions. The application of primer coat shall be in accordance with Clause 4.16.2.1 above.

Preparation of Oil Bound Distemper

The distemper shall confirm to IS 428 and shall be diluted with water or any other prescribed thinner recommended by the manufacturer.

Application of Distemper

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the primer coat. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed by immediate vertical strokes which together shall constitute one coat. The subsequent coats shall be applied after atleast 24 hours between consecutive coats to permit proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks drops etc. Application of a coat in each room shall be finished in one operation. 14 cm. double bristled distemper brushes shall be used. After each days work/brushes shall be thoroughly washed in hot water with soap solution and hung down to dry.

Protective Measures

Same as in Clause 4.16.2.1 above.

4.18.6 Waterproof Cement Paint

4.18.6.1 Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Preparation of surface shall be in accordance with Clause 4.16.2.1. The surface so prepared shall be thoroughly wetted with clean water before the paint is applied.

Preparation of Paint

Waterproof cement paint of approved make shall be mixed with- water and stirred to obtain a thick paste which shall then be diluted to brushable consistency. The proportion of mixture shall be as manufacturer’s recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

Application of Paint

The surface shall be treated with minimum two coats of waterproof cement paint. No less than 24 hours shad be allowed between two coats and the subsequent coats shall be applied only after the preceding coat has become hard to resist marking by subsequent brushing.

The finished surface shall be even and uniform in shade without patches brush marks, paint drops etc. Cement paints shall be applied with a brush with relatively short stiff hog of fiber bristles.

Curing

Curing shall be started after the paint has hardened. Curing shall be done by sprinkling with water two or three times a day. This shall be done between coats and for at least two days following the final coat.

Protective Measure

Sameas In Clause in 4.16.2.1 above.

4.18.7 Acrylic Emulsion Painting

4.18.7.1 Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Same as in above Clause 4.16.5.1 under specification of oil bound distempering

Preparation of Mix

Plastic emulsion paint shall conform to IS 5411 (Part-1) and shall be of approved shade. Preparation of mix shall be as per manufacturer's instructions.

Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be as per item description. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2/3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat.

The paint shall be applied by means of brush or roller. Before starting painting with plastic emulsion paint, the prepared surface shall be treated with two coats of primer consisting of cement, primer, whiting and plastic emulsion paint shall start only after the preceding coat has become sufficiently hard to resist brush marking. Subsequent coats of plastic emulsion paint shall also be started after the preceding coat is dried by evaporation of water content.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

Precautions

i. Brushes shall be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush. Old brushes, if used shall be completely dried of turpentine/oil paints by washing in warm soap water.

ii. No oil base putties shall be used in filling cracks/holes.

iii. Washing of painted surface shall not be done within 3-4 weeks of application.

Protective Measures

Same as in Clause 4.16.2.1 above.

4.18.8 Acrylic Copolymer Aggregate Finish

4.18.8.1 Material

It shall be an acrylic based textured wall coating consisting of quartz and silica aggregate, inorganic pigments and other additives to form a crack free, flexible, tough, waterproof coating.

Preparation of Surface

The surface to be coated shall be cleaned and all dirt, dust, grease and loose particles shall be removed. Any old textured surface shall be removed with removing agent as per manufacturer's instructions.

Application

Bonding agent and water shall be mixed first. Then the flakes/granules shall be added and mixed thoroughly and kneaded till no lumps are found. The dough shall be left for 20-30 minutes before starting application. The bonding agent, flakes/granules and water shall be mixed in different ratios for different finishes as per manufacturer’s specifications.

The first application shall be by steel trowel. It shall be smoothened, if the specified finish requires, by a plastic trowel.

4.18.9 Painting to Woodwork

4.18.9.1 Preparation of Surface

Preparation of surface shall conform to IS 2338 (Part-1) in general. All wood work shall be dry and free from any foreign manor. Nails shall be punched well below the surface. The surface shall be smoothened off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous, or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS 103.

Plywood and block board shall be treated in the same manner as for wood work. Particle board’s surface shall be filled with a thin brushable filler and finished as for solid wood.

Priming

Priming shall be in accordance with IS 2338 (Part I and II). Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied by brushing.

Priming shad be done on all exposed and unexposed surfaces. Unless specified otherwise, all joinery work intended to be painted shall receive at least 2 coats of primer.

Type of primer shall be in accordance with Table-1 and Table-2 of IS 2338(Part-II).

Stopping and Filling

Stopping and filling shall be done after priming. Stopping shall be made to the consistency of stiff paste and shall be used to fill holes and cracks. Filter shall be used to level up slight irregularities of the surface. Filler shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper.

The filler coat shall be allowed to fully flatten and harden before subsequent coat is applied.

Application of Under Coat

Under coat shall be applied after the surface has been primed, stopped and filled, and rubbed down to a smooth surface. Under coat may be brushed or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

The type of under coat shall be depending upon the finishing and in accordance with Table-1 and Table-2 of IS 2338 (Part 11).

Finishing

The finishing paint shall be as specified in the item description and shall be applied either by the brush or by spraying.

Reference shall be made to the Table-1 and Table-2 of IS 2338 (Part-II)

Application of Clear Finishes

For the application of dear finishes, the following procedures shall generally be adopted in accordance with IS 2338 (Part-I)

i) Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS 345.

Fillers shall be heavily applied to the wood surface by hand, using hessain or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by and across the grain followed by a height wipe with the grain. The filled surface shall be dried preferably overnight and smoothened with abrasive paper.

ii) Staining

a) Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

b) Oil Stains

Oil stains are solutions of oil soluble dyes in linseed oil, but, usually consist of insoluble, semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent.

c) Preparation of wood for Staining

Surface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper used in the direction of the grain. Small cracks/nail holes shall be stopped with plastic wood/fine plaster of paris. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a thinned knotting before staining. In case of oil staining stopping shall be done after staining using tinted putty or wood filler.

d) Application of Stains

Stains shall be applied by brushing, and wiping or by spraying. The stain shall be so thinned that it can be applied fairly, liberally without over staining and over lapping.

iii) Sealing

A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

Sealer may be sprayed on taking care not to flood the surface and it shall be allowed to dry hard. When fully dry the surface shall be sanded taking care not to cut through at comers and edges. Dust shall be blown off and surface wiped with a clean rag.

iv) Finishing

The stained surface shall be varnished, wax-polished or trench polished as required after it is dried.

a) Varnishing

Varnishing of wood and wood based material shall be in accordance with IS 2338 (Part-I). Surfaces to be Varnished shall be prepared to produce a smooth, dry and matt surface and all dust and dirt shall be removed from the surface.

The Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It shall be allowed to flow out white the next section is being laid in. Excess Varnish shall be scraped out of the brush and then the first section be crossed, re crossed and laid off lightly. The Varnish, once it has begun to set, shall not be retouched. In case of any mistake, the Varnish shall be removed and the work shall be started afresh.

Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flatting varnish which shall be allowed to dry hard and then be flatted down before applying the finishing coat. Sufficient time shall be allowed in between two coats.

When flat varnishing is used for finishing, a preparatory coat of hard drying undercoating of flatting varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be tightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly, and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

b) French Polish

French polish shall conform to IS 348. Suitable pigments shall be added to get the required colour. The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woollen cloth covered by a fine doth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and nigh gloss.

4.19 Sanitary and Plumbing Works (Buildings)

4.19.1 General

The work comprises supply, installation, commissioning and testing of sewerage and drainage, sanitary fixtures and fittings within including water supply the building and upto 1.0 m outside the building wall. The work includes supply of all materials as per specifications and drawings, laying, fitting, fixing, installation and commissioning of the same.

All the water supply and sanitary works shall be carried out by the licensed plumbers approved by the Employer and skilled workmen, experienced in the trade. All works shall be completely concealed either within shafts or chases or in fills and dropped ceilings unless specifically shown in drawings or required otherwise.

All work shall be adequately protected, to the approval of the Employer, so that the whole work is free from damage throughout the period of construction upto the time of handing over. No work shall be covered without approval of the Employer.

The Contractor shall be responsible for coordinating the work with works of other trades sufficiently ahead of time to avoid unnecessary hold-ups. Hangers, sleeves, recesses, etc. shall be left in time as the work proceeds whether or not these are shown in drawings.

All clamps, screws, brackets, hangers and all miscellaneous steel work needed in the work shall be fully galvanized. Only specified brand of material will be used subject to the approval of the sample.

The Contractor shall submit as directed by the Employer samples, manufacturer's drawings, equipment characteristics and capability data etc. of all equipment, accessories, devices etc. that he proposes to use in the installation, to the Employer for approval.

The Contractor shall prepare and submit to the Employer for approval before the work is commenced, all drawings. The work shall commence only after the drawings are approved by the Employer. Before the work is handed over, the Contractor shall clean all fixtures removing all plaster, stickers, rust stains and other foreign matter of discoloration of fixtures, leaving every part in acceptable condition and ready for use, to the approval of the Employer.

All sanitary ware and fittings shall conform to IS standards. The Contractor shall submit samples of all fittings and fixtures proposed to be used to the Employer for his approval. The approved samples shall remain with the Employer till the completion of the work.

All workmanship shall conform to Indian Standard Codes of Practice. The fixing and finishing shall be neat, true to level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning.

All fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of fittings. Tool marks on exposed fixtures shall not be accepted. Protective paper on fixtures shall be removed with hot water only at the final completion of work.

All the water supply, drainage and sanitary works shall be carried out strictly as per specifications, ISI codes and National Building Code with amendments upto date.

4.19.2 Bye-Laws and Regulations

The installation shall be in conformity with the Bye-laws, Regulations and Standards of the local authorities concerned, in so far as these become applicable to the installation. But if these Specifications and Drawings call for a higher standard of materials and/or workmanship that those required by any of the above regulations and standards, then these specifications and drawings shall take precedence over the said regulations and standards. However, if the drawings and specifications require something, which violates the Bye-laws and Regulations, then the Bye-laws and regulations shall govern the requirement of this installation.

4.19.3 Fees and Permits

The Contractor shall obtain all permits/licenses and pay for any and all fees required for the inspection, approval and commissioning of their installation and shall bear all expenses if any for the same.

4.19.4 Completion Certificate

On completion of the installation for Plumbing, a certificate shall be furnished by the Contractor. This certificate shall be in the prescribed form as required by the local Employer. The Contractor shall be responsible for getting the entire installation approved by the authorities concerned as required and shall bear expenses if any, in connection with the same.

4.19.5 Maintenance During Defects Liability Period

Contractor shall be required to carry out the maintenance of the Plumbing installation during defect liability period.

The Contractor shall receive calls for any and all problems experienced in the operation of the system under this Contract, attend to these within 10 hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exit. All equipment that require repairing shall be immediately serviced and repaired.

4.19.6 Water Supply

4.19.6.1 G.I. Pipes & Fittings

G.I. Pipes

All pipes for water supply inside the building shall be genuine galvanised steel tubes conforming to IS:1239 Part I (heavy grade 'C' class pipe).

The GI pipes shall be of approved make as per the list of approved makes.

G.I. Fittings

All fittings shall be malleable cast iron fittings as per IS:1879 (or as revised). All fittings shall have manufacturer's trademark stamped on it. Fittings in G.I. pipelines shall include elbows, tees, bends, reducers, nipples, union, bushes, G.I. Clamps of approved design, G.I. flanges with 3 mm rubber insertion, nuts, bolts, washers, etc. All fittings shall be tested at manufacturer's works. Contractors may be required to produce certificate to this effect from the manufacture.

Laying and Jointing of G.I. Pipes (External)

a) Trenches

The galvanised iron pipes and fittings shall be laid in trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in Table below:

Dia of Pipe	Width of Trench	Depth of Trench
15 mm to 50 mm	30 cm	60 cm

At the joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications earthwork in trenches.

b) Cutting and Threading

Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded conforming to the requirements of IS:554-1964 with pipe dies and tapes in such a manner as will not result in slackness of joints when the two pieces screwed together. The screw threads of pipes and fittings shall protected from damage until they are fitted.

c) Jointing

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped around the screwed end of the pipes. The end shall then be screwed in the socket, tee etc. with the pipe wrench. Care shall be taken that all pipes and fittings are properly jointed so as to make the joints completely water tights and pipes are kept at all times free from dust and dirt during fixing. Burr from

the joints shall be removed after screwing. After laying, the ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

d) Pipe, Coating & Wrapping

All underground pipes shall be protected by pipecoat primer and pipecoat wrapping. The pipe coat primer shall have a density of 0.92 gm/cc and drying time of 24 hours at RH 70% and temp 30 deg. C. Viscosity shall be 1000 – 2000 cps.

The pipe coat shall be a puncture resistant non-woven polyester mat 4 mm thick of high mechanical strength. The mat shall be in 7 layers. The layers shall be so arranged as to also give extra protection to high molecular high density polythene core which is the main permeable agent in the system. Pipecoat primer shall be applied on the pipe in a uniform coat leaving no drop runs.

The entire surface of pipe shall be primed without any patch left out. Unprimed surfaces shall reprimed immediately. Any uncleaned pipe shall be scraped down to surface of pipe and reprimed pipecoat primer shall essentially be in a layer for quicker drying.

The surface shall be dry at the time of applying pipecoat primer. Freshly primed pipe shall be placed on clean square cut skids and shall not be allowed to come in contact with ground or any foreign matter. It shall remain on skids until lifted or cradled after coating and wrapping operation.

All primed pipes which have excessive coat of dust accumulated over them before primer is dry or where primer has become dead, shall be primed. Drying time shall be minimum 245 hours. The application of pipecoat membrane shall be taken up soon after primer coat has dried up completely and in case within three days after priming. Otherwise fresh coat of primer shall be applied.

Membrane shall be blown under tension by means of a blowtorch. In this process, the inner surface of the membrane, being 10 micron thick polyethylene layer is burnt while at the same time the polymeric mix under it is softened taking care that the centre core is not over heated. This molten polymeric mix is then pressed over pipe surface so that no air is entrapped or voids formed underneath.

Pipecoat primer shall be applied with brushes after cleaning the pipe thoroughly. Pipecoat membrane shall be wrapped as mentioned above. No wrinkling of the wrapper shall be allowed and all overlaps shall be firmly fused to secure a firm wrapping. Coating shall be absolutely free from pinholes, bubbles and holidays.

4.19.6.2 Testing of Joints

After laying and jointing, the pipes and fittings shall be inspected under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost.

The pipes and fittings after they are laid shall be tested to hydraulic pressure of 1.5 times the working pressure. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw of traps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least two hours. The pipes and fittings shall be tested in sections as the work of laying proceeds, having the joints exposed for inspection during the testing.

4.19.6.3 Trench Filling

The pipes shall be laid on a layer of 7.5 cm sand and filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth as specified and directed and the surplus earth shall be disposed-off as directed by the Employer.

4.19.6.4 Laying and Jointing G.I. Pipes (Internal Work)

Cutting, threading ad jointing – Ref. Clause 4.17.6.1.

Fixing of GI Pipes

All exposed GI pipes shall be fixed by means of standard pattern holder bat clamps, keeping pipes 1.5 cm clear of the wall. If the pipes are fixed in chases they shall be fixed in position by iron hooks.

4.19.7 Soil, Waste, Vent and Rain Water Pipes and Fittings

4.19.7.1 Cast Iron Pipes and Fittings

Cast iron pipes and fittings to IS:3989 shall be used for soil, waste and vent pipes. Pipes and fittings with irregular bore, blow holes and other manufacturing defects shall not be allowed to be used for work.

All fittings shall be of the degree specified or as required at site.

All cast iron soil, waste, vent and rain water pipes used at basement in exposed condition or where specified shall be centrifugally cast spun iron class (LA) pipes conforming to IS 1536. These shall be with spigot and socket ends. The fittings for centrifugally cast spun iron pipes conform to IS 1538.

Holder Bat Clamps

Holder bat clamps shall be of a standard design fabricated from MS galvanised flat 32 x 1.5 mm thick and 12 mm dia. M.S, bar and 6 mm nuts and bolts. Holder bat clamps shall be fixed in cement concrete (1:2:4) blocks 100 x 100 x 100mm.

M.S. Stays and Clamps

The clamps shall be made from 2.0 mm thick MS flat of 32 mm width, bent to the required shape and size to fit tightly on the socket, when tightened with screw bolts. It shall be formed of two semi-circular pieces with flanged ends on both sides with holes to fit in the screws, bolts and nuts, 40 mm long. The stay shall be minimum one metre long of 10 mm dia MS bar. One end of the stay shall be bent for embedding in the wall in cement concrete block of size 20 x 20 x 20 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The concrete shall be finished to match with the surrounding surface.

Floor Traps

Floor taps shall be cast iron deep steal type P or S traps with a minimum seal of 75 mm. they shall be with or without vent. All traps shall be set in cement concrete blocks 1:2:4 mix without additional cost. Traps shall be provided with CP brass screwed down or hinged grating. Traps shall be provided with suitable extension piece where required with CP brass grating to flush with the floor without any extra cost.

Paintings

All pipes in ducts and exposed positions shall be painted with two coats of synthetic enamel paint of any colour approve by the Employer over a coat of primer of approved quality.

4.19.7.2 Concrete

All soil ad waste pipes below ground floor fills and in wall chases (but not in open ducts) shall be supported and covered with 75 mm cement concrete 1:2:4 in bed and all around. Encasement of such pipes shall be done after testing of pipes.

4.19.7.3 Cutting and Making Good

All pipes shall be fixed and tested as building work proceeds. Cutting and chasing shall be kept to minimum. No extra shall be allowed for cutting holes, chases etc. in wall and floors.

4.19.7.4 Jointing

a) All joints for CI soil waste and vent pipes conforming to IS:1729/IS:3989 shall be made with maleable pig lead and spun yard. Pig lead shall conform to IS:782 for caulking. Spun yard shall be of hemp and of good quality. It shall be soaked in hot coal-tar or bitumen and cooled before use. The quantity of lead to be filled per joint in various sizes of cast iron drainage pipes shall be as follows:

- 50 mm dia = 0.75 kg.
- 80 mm dia = 0.80 kg.
- 10 mm dia = 0.90 kg.
- 150 mm dia = 1.60 kg.

b) The joints for all CI centrifugally cast (Spun) iron pipes conforming to IS:1536 and fittings conforming to IS:1538 shall be made with pig lead. The quantity of lead per joint in various sizes of these pipes shall be as follows:

- 80 mm dia = 1.8 kg.
- 100 mm dia = 2.2 kg.
- 150 mm dia = 3.4 kg.
- 200 mm dia = 5.0 kg.
- 250 mm dia = 6.1 kg.

4.19.7.5 Testing

All soil, waste and vent pipes shall be tested by filling up the whole or part of stack with water. All openings for connections, etc. shall be suitably plugged.

Contractor shall remove and replace all pipes having holes, cracks, etc. All leaking joints and access doors shall be replaced or remade to the approval of the Employer. Water shall be retained in stack for a maximum period of 2 hours. After all plumbing fixtures are installed, Contractor shall apply the smoke test to the entire stack to the approval of the Employer.

The smoke test shall be carried out as under.

Smoke shall be pumped into the pipes at the lowest end from a smoke machine which consists of a bellow and burner. The material burnt shall be greasy cotton waste which gives out to a clear pungent smoke easily detectable by sight as well as by smell if there is leak at any point of drain.

4.19.8 Sanitary Fixtures and Fittings

4.19.8.1 General

All sanitary fittings are glazed earthen ware shall be 'Hindustan Sanitary Ware/Nycer/Parry' or equivalent of approved make, white in colour and of one piece construction. All metallic

fixtures like taps, stop cocks, soap holders etc. shall be of CP brass 'Parco', 'GEM' or approved equivalent make. PVC fixtures shall be of 'Caliplast', 'Brite' or equivalent approved make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

4.19.8.2 Workmanship

All sanitary ware shall be fixed in a neat workmanlike manner, true to the level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning. Cutting or making good of tiles is not permitted anywhere while fixing of fixtures and fittings.

4.19.8.3 Protection of Fixtures

Fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of chromium plated fittings. Tool marks on chromium fixtures etc. shall not be accepted.

4.19.8.4 Sanitary-ware

Indian Type Water Closet

Orissa Pan W.C. shall be 580 mm long conforming to IS:2556 Part III. The closet shall be fixed I the floor with 150 mm thick sand cushion and shall be connected with 100 mm dia C.I. or stone ware S or P trap. The closet shall also be fitted with a low level earthen ware cistern conforming to IS 774 of 12½ litres capacity with wiped solder joints, internal overflow arrangement, 40 mm dia C.P. flushing pipe. The cistern shall be fixed on MS or CI Brackets at a minimum height or 610 mm from top of pan. All exposed metallic surfaces shall be painted with two coats of white enamel paint of approved quality over a coat of primer.

Orissa Pan type W.C. of size 580 mm long with concealed 32 mm dia flush valve push button/lever with regulator or 'Nelson', 'Orient' or approved equivalent, CP flush pipe and clamp with rubber joint to W.C. complete including cutting walls and floors and making good the same.

Wash Down Type Water Closet

Wash down water closet shall be pattern 1 conforming to IS:2556 Part II. This shall be fixed with plastic seat and cover as per IS:2548 of 'Brite' or approved equivalent make, fixed with CP brass hinges and rubber buffers and an integral 100 mm dia 'S' or 'P' trap with anti-syphonage vent horn.

A low level earthenware cistern conforming to IS:774 of about 10 litres capacity, with 15 mm dia PVC inlet pipe and brass union with wiped solder joint, internal overflow arrangement, 40 mm dia CP brass flushing pipe, CI or MS supporting brackets shall be fixed with the water closet. The closet shall be fixed firmly in the floor with matching cement mortar. All exposed metallic surface shall be painted with two coats of white enamel paint of approved quality over a coat of primer. The cistern shall be fixed at a height not exceeding 300 mm between the top of the pan and the underside of the cistern.

Urinals

Half stall type urinal shall be conforming to IS:2556 Part VI. These shall be mounted on walls. The flushing inlet pipe shall be of CP brass 15 mm dia and waste pipe 32 mm dia G.I. 750 mm long, with necessary unions and CP bottle trap. Rawl plugs with CP brass screws, shall be used for fixing the urinal. Fixing shall ensure that no liquid is left over in the pan after flushing. Unless otherwise indicated height above finished floors shall be 650 mm.

Urinals shall be connected to automatic flushing cistern either individually, or in groups where individually connected to flushing cistern, the cistern capacity shall be 5 litres. For two urinals, one cistern of 10 litres capacity and for three urinals, one cistern of 15 litres capacity shall be provided.

Cistern inlet shall be 15 mm dia PVC pipe with brass union. Outlet pipe from cistern shall be 25 mm CP brass main, with 15mm CP distributor pipe of sufficient lengths to reach each bowl. Where individual cisterns are provided, the outlet shall be of 15 mm CP brass. All expose metallic surfaces shall be painted with two coats of approved white enamel paint over a coat of primer, cistern interior shall be painted with two coats of anticorrosive paint of approved quality, wherever called for the waste from urinals shall be collected and disposed through concealed pipes and suitable means to clean and maintain the system shall be provided.

Wash Basin

Wash basin shall be flat back of 550 mm x 400 mm size with one tap or two tap hole confirming to IS:2556 Part –IV. This shall be fitted on CI or MS brackets conforming to IS:775. Brackets shall be given two coats of white enamel paint or enamel paint or aluminium paint, over a coat of primer.

The wall side shall be fixed well flushed with the plaster of wall and the joint if any, shall be properly stopped with mortar and painted white. Pillar cocks, PVC connecting pipe with brass union, a CP brass bottle trap with union, CP brass chain and rubber PVC stopper, 32 mm dia, GI waste pipe shall also be supplied and fitted with the wash basin, the top of rim of the wash basin shall be fixed at 800 mm above finished floor level unless otherwise specified.

Mirrors

The mirror shall be of the best quality of 'Atul'/'Swastic' or equivalent approved make of size 600 mm x 650 mm x 5.5 mm thick. The mirror shall have ½" thick commercial board backing and shall be provided with aluminium beading all around. It shall be fixed to the wall on wooden blocks with CP brass screws and CP washers.

Sink

Providing and fixing stainless steel sink of size 485 mm x 385 mm c 190 mm deep or nearest equivalent with R.S. or CI brackets, 40 mm CP waste, CP brass chain and rubber plug, 4 mm CP. Cast brass bottle trap, with pipe to wall and CP wall flange, rubber adapter for waste connection.

Towel Rail

Towel rail shall be of aluminium/C.P. brass pipe with suitable brackets. The tower rail shall be 20 mm dia and 1.25 mm thick 600 mm long. It shall be approved by the Employer. It shall be fixed at specified locations shown in the drawing or as directed by the Employer.

Liquid Soap Container

The liquid soap container shall be of superior quality chromium plated brass of 'PARCO', GEM make or equivalent as approved by the Employer. It shall be fixed with CP brass screws on wooden cleat.

Showers

The shower head shall be chromium plated brass, 100/150 mm dia with holes of one millimeter diameter each is sufficiently large for all ordinary requirements. It shall be fixed at a height of 2.0 m from floor level or as directed by Employer. It shall conform to IS:2064.

Toilet Paper Holder

Toilet paper holders shall be of chromium plated brass as approved by the Employer. It shall be 100 mm long. It shall be fixed on wooden cleats as directed by Employer.

Coat and hat Hooks

Coat and hat hooks shall be chromium plated brass of 'Ego' or equivalent as approved by Employer. They shall be fixed on teak wood plate of 75 mm x 75 mm and 12 mm thick. Teak wood plate shall be properly polished. Wooden cleats shall be inserted in wall to fix wooden plates. CP brass screws shall be used.

Bib and Stop Cocks

Bid and stop cocks of screw-down type shall conform to IS:781. All taps shall be of heavy grade. The taps shall be chromium plated brass or ordinary brass easy cleaning type as specified.

HCI Nahni Trap (Floor Trap)

Nahni trap shall be of heavy cast iron as per IS:3989 with 100 mm inlet and 80/100 mm outlet with CP pressed steel grating. It shall be of self-cleaning design (Grating shall be of either hinged or screwed down type).

It shall be fixed in cement mortar 1:2 and as directed by Employer.

Stoneware Gully Trap Chamber

The square mouth gully trap shall be of 100 mm dia, conforming to IS:651 of specified and/or approved quality stoneware, complete with cast iron grating, and shall be got approved by the Employer. The size of CI frame and cover shall be 300 mm x 300 mm. It shall be properly fixed as directed by the Employer.

The size of the chamber shall be 300 x 300 x 675 mm (internal). It shall be constructed of brick masonry walls 115 mm thick in 1:4 cement mortar and M-15 concrete foundations. Inside and outside faces of the masonry walls shall be plastered with 1:3 cement mortar. The top of the chamber shall be provided with CI cover and frame.

Brick Masonry (Manholes/Inspection Chamber & Valve Chamber)

The size of the manholes and valve chambers shall be as specified in the drawings. It shall be constructed of brick masonry walls 230 mm thick in CM 1:4 (1 cement:4 sand) resting on M-15 concrete foundations. The inside and outside faced of the masonry wall shall be plastered with 13 mm thick plaster of cement mortar 1:3 (1 cement : 3 sand).

The top of the chamber shall be provided with reinforced concrete M-20 grade slab as per drawing and directions of the Employer. MS rungs made out of 16 mm dia MS bars shall be fixed inside the manhole as shown in the drawing after applying two coats of anticorrosive paint.

Valve chambers shall be provided and fixed with a light duty CI cover and frame. The top of chamber shall be provided with reinforced cement concrete M-15 grade as per drawings and direction of the Employer.

The CI manhole covers and frames shall conform to IS:726. The type, size and grade shall be as per drawing and direction of the Employer. The frame shall be fixed in position during concreting of top slab, inside faces of frame and cover shall be given two coats of approved anti-corrosive paint.

The specification for brick masonry, plastering, concreting, excavation and back filling, etc. as given under relevant clauses shall be applicable for this work also.

Gun Metal Valve

All full way and globe valves shall be heavy gunmetal and tested at 300 psi and shall be approved by the Employer. Valves shall conform to IS:778. Size of valve chamber shall be as per item description, construction of valve chamber shall be carried out as detailed above. Valve chamber shall be provided & fixed with heavy duty CI surface box conforming to IS:3950. The surface box shall be hinged pin open type & shall be fixed in the chamber slab. It shall have a hole for opening.

Marble Partitions

The marble partition shall be 25 mm thick and approved by the Employer. The edges of marble shall be cut by machine to have proper smooth edges. Vertical face shall be fixed in position with cement mortar (1:3) as directed by the Employer for minimum depth of 100 mm in the wall. It shall be polished after fixing. Two horizontal faces shall be supported by MS channels of size 35 mm deep embedded into wall.

4.20 Water Supply and Distribution System

4.20.1 General

This specification covers the installation and commissioning of the complete water supply distribution system with in the terminal area including the supply of potable water to ships and buildings and the supply of raw water for landscaping and greenery.

Two numbers of pumps (1 W + 1 S) shall be provided to pump potable water from UG sump to overhead tank with nominal pressure.

4.20.2 Material

4.20.2.1 Pipe

Piping for supply and distribution lines shall be HDPE pipes conforming to IS: 4984.

4.20.2.2 Fittings and Specials

Fittings and specials shall be suitable for 10 bar pressure rating, unless otherwise specified. Fittings and specials shall conform to Indian standards.

4.20.3 Execution

4.20.3.1 Installation

Cutting of Pipe

Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise recommended by the manufacturer and authorized by the Employer, cutting shall be done with an approved type cutter.

Adjacent Facilities

Water Lines

Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric wiring.

Joint Deflection

The maximum allowable deflection shall be as per Indian standards. If the alignment requires deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth.

Placing and Laying

Underground pipes shall be laid in accordance with IS:12288:1987. Pipe shall be laid to the grade calculated by the Contractor or as indicated by the Employer. Pipe alignment shall be straight between bends and curves within a tolerance of + 5 mm.

All bends of 11¼ degrees and greater shall be made with the proper fittings. Joint deflection shall be limited to the maximum recommended by the manufacturer. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid. Pipe shall not be laid in water or when trench conditions are unsuitable for the work. Water shall be kept out of the trench until joints are complete. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substance will enter the pipes or fittings. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored.

Service Lines

Service lines shall include the pipeline connecting building piping to water distribution lines to the connections with the building service at a point approximately 1.5 m outside the building where such building service exists. Where building services are not installed, the Contractor shall terminate the service lines approximately 1.5 m from the site of the proposed building at a point designated by the Employer. Such service lines shall be closed with plugs or caps.

4.20.3.2 Tests and Inspection

The mains shall be slowly filled with water to expel all air from the system and shall be left to stand full of water for a period of not less than 24 hours.

Test pressures shall be applied by means of a manually operated test pump or in the case of long mains by a power driven test pump, which shall not be left unattended. Adequate precautions shall be taken to ensure that the specified test pressure is not exceeded.

The specified test pressure shall be maintained for a period of 1 hour and if there is any leakage it shall be measured by the quantity of water pumped into the main. The main shall be deemed to be satisfactory if the loss of water does not exceed 3.5 litres per 100 mm nominal bore, per kilometre, per bar of test pressure per 24 hours.

Any defect or visible individual leak observed during the hydrostatic pressure testing shall be repaired by the Contractor at his own expense in the manner directed by the Employer.

Should losses from the main exceed the specified amount, testing shall be repeated until the main is deemed satisfactory and is accepted by the Employer. All labour, material and equipment for testing shall be deemed to be included in the rates.

These tests shall be conducted on the entire water distribution system by sections of 500 meters as a maximum on the general circuit, and by building, for the distribution from the main network. All of the installations must undergo the pressure tests.

4.20.3.3 Cleaning and Disinfection

After the water distribution system has been tested, the Contractor shall proceed to clean the system with water, followed by disinfecting of the entire network. This disinfecting shall be carried out according to a method proposed by the Contractor for approval by the Employer, and according to the provisions indicated above and the current regulation of the Government of India

4.21 Sewerage Collection & Transfer System

4.21.1 General

The intent is to install a sewerage system in the yard area to cater to the collection and transfer of sewage generated from Buildings and Toilet Block.

4.21.2 Scope

The scope covers collection of all sewerage from all terminal buildings & Toilet Block to the collection pit/septic tank. The sewerage system within the buildings and to a distance of one meter from the buildings is included in the scope of respective building.

The scope of work shall include pipe and appurtenant structures and building sewers to points of connection with the building drains 1.5 m outside the building to which the sewer system is to be connected and drain all sanitary sewerage to septic tanks and dispose-off the effluent as given in IS:2470 (Part 2). The system includes furnishing and installing sanitary sewers systems and appurtenances complete for this Contract.

Systems of pipes and appurtenances are to be sized by the Contractor according to the standard usage for sanitary sewers. Scope also consists of furnishing transportation, labor, equipment, and materials to construct sewerage system in accordance with their own Design and Drawings. All products and execution shall be subject to prior approval by the Employer.

The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Employer.

4.21.3 Material

4.21.3.1 Pipe

Sewer pipe and fittings shall be concrete NP3 grade conforming to IS: 458 Codes. All reinforced concrete pipes shall be class NP3 conforming to IS: 458. RCC pipe of class NP4 type shall be used below road. Before being laid, the pipe and fittings shall be carefully inspected for defects, those not meeting the foregoing specifications shall be rejected.

4.21.3.2 Manholes

The manholes shall be made of reinforced cement concrete of grade M25. PVC encapsulated foot rests shall be built into the wall of the tank at 300 mm intervals below each of the manholes, they shall be set staggered in two vertical runs at 200 mm centers horizontally the top footrest shall be 450 mm below the manhole cover and the lowest not more than 300 mm above the floor of the tank.

It must be possible to install the pipe in the wall of the manhole without touching the walls perpendicular to that wall. Manholes types and construction shall be submitted for the approval of the Employer. The covers shall be equal to heavy roadway type made of ductile iron, with frame of cast iron Ft. 20 for closed manholes.

4.21.3.3 Septic Tank

A septic tank is a combined sedimentation and digestion tank where the sewage is held for one to two days. This shall be provided at suitable location. During this period the suspended solids settle down to the bottom. This is followed by anaerobic digestion of settled solids (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in bio-degradable organic matter and release of gases like carbon-dioxide, methane and

hydrogen sulphide. The effluent although clarified to a large extent, still contain appreciable amount of dissolved and suspended putrescible organic solids and pathogens.

Design

Septic tank shall be water tight, single storeyed, underground, rectangular in shape, single or double tank having roof. In case of double tank, the first compartment is usually twice the size of the second. The liquid depth is 1 – 2 m and the length to breadth ration i.e. 2.3 to 1. The sizes of the septic tank shall be based on IS: 2470 (Part I).

Construction Details

The inlet and outlet should be located at different levels to avoid disturbance due to the force of water entering or leaving the tank. Every Septic tank should be provided with ventilation pipes, top being covered by mosquito proof wire mesh. The height of the pipe should extend at least 2 m above the top of the highest building within a radius of 20 m.

Septic tanks, constructed in concrete cast in-situ shall be provided with watertight covers of adequate strength. Access manholes of adequate size shall also be provided for purpose of inspection and desludging of tanks. The floor of the tank should be sloped towards the sludge outlet.

Sludge Withdrawn and Disposal

Portable pumps may be used for desludging. Mechanical vacuum tankers may preferably be used to empty the septic tanks. Yearly desludging of septic tank is desirable while desludging a depth of 2.5 cm of well-digested sludge is left at the bottom of the tank for further anaerobic action

Secondary Treatment and Disposal of Effluent

The septic tank effluent contains sizable portion of dissolved organic content and pathogenic organisms and hence need to be treated before its final, safe disposal. Depending on the position of the sub-soil water level, soil and subsoil conditions, size of the installation, resource available etc. The extent and type of secondary treatment facility may vary from the most conventional land disposal methods like soak pits or dispersion trenches to additional secondary biological treatment system.

4.21.4 Execution

4.21.4.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches.

4.21.4.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement. The length of pipe shall be pressure tested as per Indian Standard.

4.21.4.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.21.4.4 Waste Water Treatment Plant

4.21.4.4.1 General

The treatment plant of 50 KLD (MBR System) shall be provided which should be compact, odour free and shall consume low power.

Plant shall be installed below ground level or at any desirable depth and shall generate minimum amount of excess sludge. Waste water after treatment below shall be suitable for gardening/ Road washing.

Total waste water generation from terminal will be about 40 KLD. The entire waste water passes through bar screen chamber, Oil & grease separator to remove oil and grease and then treated in ETP cum STP (Capacity 50 KLD). Treated water should be used for horticulture purpose at the site and dust suppression purpose.

The effluent generation is expected through the following activities at the IWT Terminal:

- From Domestic Water Consumption – Domestic Waste Water from Office toilets & Canteen.
- From Vessels waste water receipt facility - Oil mixed Bilge water effluent and domestic waste water from toilet & canteen.
- From Truck Washing & Miscellaneous usages – Washing effluent water with small quantity of Oil & Grease.

Parameters for design of ETP cum STP (Compact MBR System):

Natural of Effluent	Domestic Sewage
Daily Average Flow	50 cum/day **
pH	6.0 – 8.8
BOD	280 – 380 Mg / L.
Suspended Solids	200 – 480 Mg/L.
COD	600 – 800 Mg / L
Oil & Grease	20 Mg/L
Coliform count	< 106 – 107 (Assumed)

** If the input flow is less, then the system can be operated automatically in the following two ways:

1. On and OFF of the pump will be controlled by a level sensor and the system will work at the design flow. Whenever there will be waste water in the system – at that time pump will work.
2. If the input flow is known, then the flow of pumps needs to be throttled and the system will be working in a controlled flow.

In both cases, the dosing of chemical in primary treatment needs to be taken care of.

Standards of the Effluent Discharge after treatment shall be as follows:

Parameters	Value
pH	6.0 – 8.8
BOD	Less than 20 Mg/L
Suspended Solids	Less than 10 Mg/L
COD	Less than 180 Mg/L
Oil & Grease	Less than 10 Mg/L
Coliform count	<103 at the CCT outlet

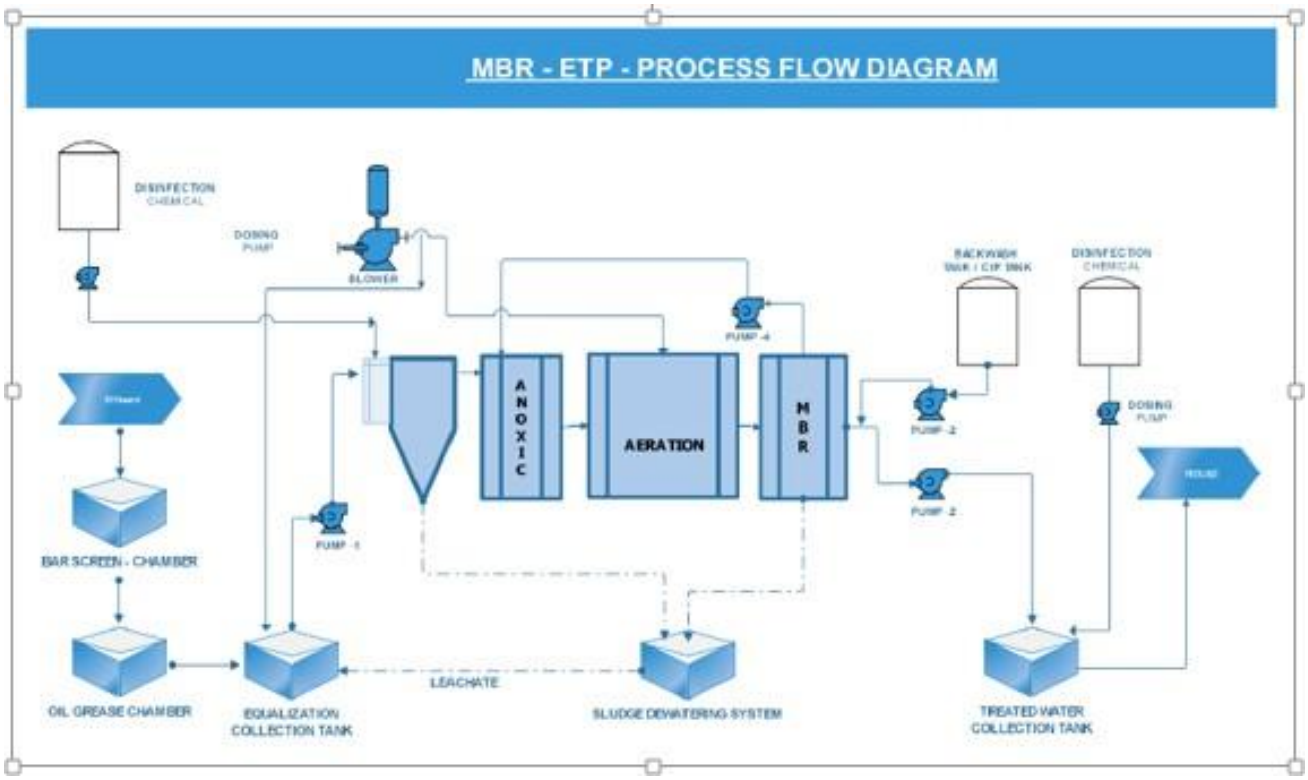
4.21.4.4.2 Process description

In order to conserve water, the treatment plant shall be designed to ensure that treated effluent (water) characteristics are well below the permissible limits, even under varying flow conditioning which are typical for such systems.

Considering the contaminants which are present in the combined effluent, the following treatment scheme is to be considered.

- The effluent from the above three activity will be collected in a collection cum Equalization Tank, of suitable capacity, where all the effluent will be mixed and stored for further treatment.
- The combined effluent from equalization tank will be pumped to a Tilted Plate Interceptor Unit, which will be basically a Gravity Separator which utilize the difference in specific gravity between two phases of liquid (predominantly for removal of free oil in water) as the principle of separation. The high surface area for separation will be provided by a lamellar arrangement of plates which also reduces the plant space requirement.
- The floating oil with water from the Tilted Plate Interceptor will be removed to a storage tank, installed with an Oil Grease Skimmer, for further separation of oil from water. Oil can be collected in MS barrels, for disposal as per Hazardous Waste Management Rules 2016 through authorized approved vendors of SPCB. Water after separation will be taken back to flash mixer. The sludge which will be in the form of slurry will get settled to the bottom of Interceptor and will be decanted to the sludge collection tank.
- The effluent after oil & grease removal from Interceptor will be sent to a Flash Mixer with arrangement of dosing Alum solution, prepared in a separate tank. The purpose of Alum dosing is to coagulate the suspended solids in the incoming effluent.
- The effluent mixed with alum will be fed to a Flocculater, with arrangement of dosing of Polyelectrolyte Chemical in a solution form. The Polyelectrolyte functions as a Flocculating agent, and helps the fine dust particles to settle down in the clarifier.
- The effluent mixed with Alum & Polyelectrolyte will be fed to a Primary Clarifier for settlement of suspended solids. The incoming effluent is expected to have 300-500 ppm of Suspended Solids, which will be reduced to less than 50 ppm, in the outlet water. The settled solids in slurry form will be removed from the clarifier bottom and sent to sludge collection tank.
- The clarified water will be fed to an Aeration Tank, installed with a diffuser aeration system. The aeration will help in biological treatment of the effluent.
- The effluent from aeration tank will be fed to Secondary Clarifier, where the particulate load after biological treatment will settle down.
- The clarified water will be stored in a Filter Feed Tank, for further filtration through Pressure Sand Filter & Activated carbon Filter. The back wash water from these filters is fed to the sludge storage tank.
- The filtered water will be stored in a tank, with arrangement for Chlorination, as disinfectant. This water will be stored in a treated water storage tank, for usage in Gardening/washing etc.
- The sludge collected from Tilted Plate Interceptor, Primary Clarifier & Secondary Clarifier is stored in a Sludge Collection holding Tank. The slurry from this tank will be pumped to a Filter Press, which concentrates the slurry, which is removed as cake for disposal. The filtrate from filter press is taken back to flash mixer.

CONCEPTUAL FLOW DIAGRAM



4.21.4.4.3 Special notes

- Cost of pump shall include provision of isolation valves at inlet and outlet, non-return valves at outlet, pressure gauge, and steel channel arrangement at base, power and control cable from and to electrical panel, level controllers and alarm system.

  - Providing of air educator system shall be made for following through MS epoxy painted piping, fittings and valves.
  - Sludge recycle piping from clarifier.
  - Sludge wasting piping from clarifier.
  - Skimmer return piping from clarifier.
  - Contractor to note that All submersible pipelines shall be in SS 304

- A dedicated sewage pump with flexible pipe at suction end and discharge end at jetty. The capacity of the sewage pump shall be 5 Cu.m/hr. and 3.0 bar head. This sewage pump shall take out the sewage of the ship tanker through a flexible pipe at suction side of the pump and it shall discharge the sewage in the road sewage tanker. Road sewage tankers will transfer the collected sewage to ETP cum STP.

4.22 Waste Collection Center

The specifications for earth filling shall be followed as provided in section 4.7. The sub grade shall be prepared by compacting top 2 m soil in layers of 225 mm with road roller; in which the top layer of the ground is then compacted with stone aggregate of specified sizes in uniform thickness by a vibratory roller to proper grade and camber.

Waste generated at the terminal shall be segregated by providing different color bins at location of waste collection center for recyclable and non- recyclable waste. Recyclable waste shall be sold to authorized vendors and non- recyclable waste shall be disposed off regularly through authorized agency in area responsible for waste collection and management. Oil waste generated from incoming barges & vessels and equipment/machinery at the terminal shall be stored and disposed off to authorized recyclers.

4.23 Masonry Boundary Wall

4.23.1 General

This section of the specifications includes the requirements for furnishing and installing of masonry boundary wall and barbed wire fencing Y shape on top of the wall and appurtenances as required providing a complete security system.

4.23.2 Materials

Refer specifications under 'Materials'.

4.23.3 Workmanship

The purpose of fencing is to provide a solid uninterrupted stone masonry boundary wall around the port area, and keeping only openings being the road. Stone boundary wall shall be erected and installed by professional organization who are regularly engaged in this business, employing skill labour in this type of work to provide a complete security fencing system.

Refer to specifications under Plain and Reinforced Concrete for the different concretes and reinforcing steel for the construction of the boundary wall. Refer to specifications under Stone Masonry Work for the construction of the boundary wall. Refer to specifications under Structural Steel Work for the construction of the fence and appurtenances as required.

4.23.4 Construction

The Contractor shall submit for approval shop drawings of fencing, and appurtenances and shall not proceed with abreaction and installation thereof prior to approval by the Employer. The location and alignment of the boundary wall shall be planned by the Contractor with the approval of the Employer. The wall shall be able to withstand the collision of vehicle with a speed of 10 km/hr.

The masonry boundary wall shall have stone masonry foundation with cement mortar 1:4 (1 cement: 4 coarse sand) on lean mix concrete 1:3:6 (1 cement: 3 coarse sand: 6 aggregates) base. Minimum height of the wall shall be 2.4 m. Reinforced Concrete (Grade M-25) coping breams shall be constructed on top of stone masonry wall. Barbed wire fencing Y shape on

top of the wall with minimum height of 1.0 m shall be provided. Expansion joints shall be provided at 30 m centre to centre.

Barbered wire shall be fastened to the Y angles with wire ties at adequate spacing. Painting to the masonry boundary wall and structural steel shall be as per specifications under painting.

4.23.5 Clean Up & Repair

Upon completion of the masonry boundary wall, the Contractor shall clean all soiled places and repair the damages if any to the approval of the Employer.

4.24 Berth Appurtenances

4.24.1 General

This specification includes requirements for furnishing, constructing and placing all berth appurtenances complete in all respects including but not limited to the following:

- Fenders
- Bollards
- Ladders
- Mooring rings
- Rubbing strip
- Edge angles
- Handrails
- Expansion joints
- Drain pipes

4.24.2 Fenders

For the jetty, suitable type fenders of Trelleborg make or any other equivalent fenders shall be used. The supplier of the fenders should be actively involved in erection of fenders.

4.24.2.1 Materials

Rubber

The material used for the fender shall be natural or synthetic rubber of high quality having sufficient resilience, anti-aging, weather-resistant and wear-resistant properties to meet all normal service conditions. The material shall be homogeneous without any defects, impurities, pores, cracks etc. and generally have the following properties:

PROPERTY	TEST STD & CONDITION		CRITERION	EQUIVALENT INTERNATIONAL STD		
				ASTM	BS ISO	DIN
TENSILE STRENGTH	JIS K6251 NO. 3 DUMBBELL	BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	16 MPA MIN. MORE THAN 80% TO ORIGINAL	D412	BS ISO 37 BS 903 A3*1	DIN 53504
ELONGATION		BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	360% MIN. MORE THAN 80% TO ORIGINAL			

HARDNESS	JIS K6253 DUROMETE R A	BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	82 MAX. LESS THAN +8 TO ORIGINAL	D2240	BS ISO 48 BS 903 A26*1	DIN 53505
AGEING	JIS K6257	70 DEG X 96 HRS		D573	BS ISO 188 BS 903 A19*1	DIN 53508
COMPRESSI ON TEST	JIS K6262	70 X 24 HRS	30% MAX	D395	BS ISO 815-1 BS 903 A6*1	DIN 53517
TEAR RESISTANCE	JIS K6252	CRESCENT TYPE	70N/MM MIN	D624	BS ISO 34-1 BS 903 A3*1	DIN 53507
ABRASIVE WEAR	JIS K6264	AKRON METHOD	1.5CC MAX	D5963-04	BS ISO 4649 BS 903 A9	DIN 53516
BOND STRENGTH	JIS K6256-2	90 DEGREE	7N/MM MIN.	D429	BS 903 A21.1	
SEA WATER RESISTANCE	JIS K6258	3% NACL SOLUTION 23 DEG X 24 HRS	VOLUME CHANGE +10%/-5% MAX. HARDNESS CHANGE +/- 10 MAX	D471	BS ISO 1817 BS 903 A16*1	
OZONE RESISTANCE	JIS K6259	50PPHM 20% ELON. 40 DEG X 72 HRS	NO CRACK	D1149	BS ISO 1431-1 BS 903 A43*1	DIN 53509
DENSITY	JIS K6268		1.1 g/cc to 1.30 g/cc	D1817	BS ISO 2781 BS 903 A1*1	

Accessories

The materials for fender accessories shall generally conform to the following requirements

i) Protector (Frontal) Panels Frame shall be made of rolled steel to ASTM A441 or equivalent

ii) Bolts, nuts and washers used for fixing the Protector Panel Frame to the Fender Body shall be of stainless steel to AISI 304 or equivalent

iii) Shackles and turnbuckles where required shall be galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent

iv) The chain and its components shall be sized to withstand the maximum loads with a minimum factor of safety of three on breaking strength, but with a stock size of not less than 30 mm. Suspension chains shall have provisions for field adjustment. All chains and padeyes for attaching chains shall be hot dip galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent subject to approval of the Employer

v) U-anchor where required shall be of stainless steel to AISI 304 or equivalent

vi) The material for resin anchor sleeve shall be made of synthetic resin and proved satisfactory to the following requirements

Physical Properties:

Tensile Strength (23oC)	-	Min 300 kg.sq. cm ASTM 638
Water absorption (weight change)	-	Max 3%
Chemical resistance to 10% NaCl (weight change)	-	Max 1%
Elongation (23oC)	-	20% ASTM 638

vii) The anchor bolt shall be made of stainless steel to AISI 304

viii) Frontal pads shall be provided with low function UHMP protective pads

Dispatch of Fenders

Fenders shall not be dispatched from manufacturer's works to the Site without the written consent of the Employer.

4.24.2.2 Performance Verifications

All testing shall define fender performance under linearly-decreasing or sinusoidal-decreasing deflection velocities to simulate actual, vessel-berthing conditions.

Rated Performance Data (RPD), manufacturer's published performance curves and/or tables, shall be based on:

a) Initial berthing velocity of 0.25 m/s and decreasing to no more than 0.005 m/s at test end

b) Testing of fully broken-in fenders;

c) Testing of fenders stabilized at 23C ± 5C

d) Testing of fenders at zero degree angle of approach

e) Berthing frequency of not less than one hour

Catalogues shall also include nominal performance tolerances as well as data and methodology to adjust performance curves and/or tables for application parameters different from RPD conditions. Adjustment factors shall be provided for initial velocities, temperatures and contact angles. Adjustment factors for velocity and temperature shall be provided for every catalogue rubber compound or other energy-absorbing material offered by each manufacturer.

4.24.2.3 Fender Testing

Performance testing to establish design data may use either of two methods as mentioned in PIANC Guidelines for the Design of Fenders Systems–2002

- The traditional and widely used Constant Velocity (CV) Method and
- Decreasing Velocity (DV) Method

4.24.2.4 Test Apparatus

The test apparatus shall be equipped with a calibrated load measuring device such as load cell(s) or pressure transducer and linear transducer(s) for measuring displacement capable of providing continuous monitoring of fender performance. The test apparatus shall be

capable of recording and storing load-cell and transducer data at intervals of 0.01H-0.05 H, where H is a fender's nominal height, and storing manually-entered inputs. Also information related to serial nos., date, time at start, test ambient temperature etc. shall be furnished.

For fender tests, all equipment used to measure and record force and deflection shall be calibrated, and certified accurate to within ± 1(one) percent in accordance with ISO or equivalent JIS or ASTM requirements. Calibration shall be performed within one year of the use of the equipment, or less, if the normal calibration interval is shorter than one year. Calibration of Test Apparatus shall be checked annually by a qualified third-party organization, using instrumentation, which is traceable to a certified, national standard.

4.24.2.5 Test Protocol

The performance test shall deflect specimens according to either of the two methods, Method CV or Method DV. Clear and unambiguous calculations must be provided for any adjustments made to the test results.

4.24.2.6 Supporting Protocols

Supporting Protocols shall cover temperature stabilization, Velocity Factor (VF) and Temperature Factor (TF) as mentioned in PIANC Guidelines for the Design of Fenders Systems – 2002.

4.24.2.7 Verification/Quality Assurance Testing

Energy/Reaction Compliance Testing

Samples for verification testing shall be actual fender elements fabricated for the project following the PIANC Guidelines for the Design of Fenders System – 2002. A minimum of ten percent of the fender order shall be tested for compliance with energy/reaction requirements.

Break in Deflection

Break-in deflection of actual elements should be at least manufacturer rated deflection. At least one cycle should be performed.

Other Testing

Effect of contact angle and durability tests should be carried out as per PIANC Guidelines for the Design of Fenders Systems – 2002 recommendations.

4.24.2.8 Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

4.24.2.9 Steel frame, Frontal Frame, Hardware, Chains and Related Accessories

All steel hardware for securing of fenders shall be stainless steel grade AISI 304 or equivalent. All hardware shall be of sufficient capacity to safely resist all normally anticipated loading conditions. Chain anchor assemblies shall be designed to resist the maximum loads with a minimum factor safety on breaking strength and concrete pillion of four.

4.24.3 Bollards

4.24.3.1 General

Cast Steel bollards to be installed on the Jetty as required for the spectrum of vessels to be berthed at Jetty and they should not be protruding out. The bollards have to withstand sudden jerking effect from ropes connected to vessels and to resist rubbing effect of ropes on its sides. For the proposed Jetty minimum 30 T capacity bollards shall be provided.

The Contractor shall provide bollards of suitable type at all locations of jetty. Painting and numbering of the bollards shall be done.

4.24.3.2 Standards and Codes

The following latest editions of standards and codes or approved equivalent international codes shall be followed for the manufacturing and testing of cast steel bollards.

IS 1030 - Specifications for carbon steel casting for general engineering purposes

IS 1387 - General requirements for supply of metallurgical materials

IS 3664 - Code of practice for ultrasonic Pulse Echo Testing by contact & Immersion methods

IS 1599 - Method for bend test for steel products other than sheet, strip, wire & tube

IS 1608 - Method of tensile testing of steel products

4.24.3.3 Classification

The casting shall conform to IS 1030. The mechanical properties of it shall be:

- Tensile strength : 540 MPa (min.)
- Elongation : 15% (Gauge length 4JA)
- Yield strength : 50% of min. tensile strength
- Angle of bend : 60% (min.)

Chemical composition:

The limit for sulphur and phosphorous in the steel when analysed shall be as follows:

- Sulphur : 0.05% max.
- Phosphorous : 0.5% max.

4.24.3.4 Specifications for Casting

4.24.3.5 Method of Casting

The steel for the casting can be made from open hearth, electric, duplex, acid Bessemer, basic oxygen (L.D) or a combination of these processes.

Castings manufactured from steel made by Bessemer processes will not be accepted. The steel shall conform in quality, strength, hardness etc. to IS 1030.

The casting shall be made under strictly controlled condition to ensure chemical composition, soundness, uniformity, correct grain size to develop shock resistance properties and to avoid any blow-holes.

4.24.3.6 Moulding and Moulding Tolerances

The casting shall be accurately moulded in accordance with the drawing. The dimensional tolerance that can be allowed for all important dimensions shall be ± 1.6 mm. The thickness of casting shall in no instance be greater than or less than 1.6 mm.

The castings shall be sound, clean and free from sand. They shall be free from distortion, blowholes, twists and other injurious defects. They shall be properly flattened and dressed.

4.24.3.7 Heat Treatment

All casting shall be supplied in the heat treated condition which shall be carried out at suitable temperature to give the mechanical properties as specified. The casting shall thoroughly be annealed to refine the crystalline structure throughout the casting by heating to a uniform temperature not less than the normalizing temperature and allowing to cool slowly from maximum temperature in a uniform manner or alternatively normalizing by heating in a similar manner and allowing it to cool in air away from draughts.

In no case it shall be allowed to conduct heat treatment process for more than two times on the same casting. The Contractor shall furnish to the Employer, the method of heat treatment and all relevant records.

4.24.3.8 Marking Procedure

Each casting shall be legibly marked with

- Number or identification mark by which it can be traced to the melt from which it was made, and
- The manufacturer's initial and trade mark
- The capacity of the bollard

4.24.3.9 Defects and rectification

If the casting is found defective during the course of any subsequent preparation or machining, it shall be rejected even if it has been found satisfactory during earlier testing, if any.

No casting shall be repaired or welded without the prior permission of the Employer or his representative. When repairs that might have been so sanctioned are completed, the concerned casting shall be again presented for inspection. When welding is carried out, the welding technique and the preparation of the casting for repairs shall be accordance with IS 5530.

4.24.3.10 Inspection

The Employer shall have free access to the works of the manufacturer at all reasonable times during the manufacture of the castings. He shall be at liberty to inspect the manufacture at all stages and to reject any casting or material that is unsound and does not otherwise conform to the terms of this specification.

4.24.3.11 Testing

Test Sample

All test samples shall be cast in the presence of the Employer or his representatives and shall be tested in his presence. The test samples shall be cast separately from the casting. The test sampling shall be cast from moulds of the same material, which is used for casting and shall be poured at the same time and from the same melt as the casting they represent. The samples shall be treated along with the casting they represent.

The test samples shall be provided to the extent of 2% of the number of casting from each melt but in no case less than two samples per melt. When a casting is made from more than one melt, at least four tensile tests and four bend tests shall be made from samples situated as far apart as possible in the casting. Some of the test samples shall be taken as near the top and others from as near the bottom of the casting as is practicable.

The test samples shall be stamped in presence of the Employer so as to identify the casting to which they relate.

Type of Test

i) Tensile Test

The tensile test shall be carried out in accordance with IS 1608. The minimum tensile strength and elongation shall be as given earlier in this specification

ii) Bend Test

The bend test shall be carried out in accordance with IS 1599. This test piece shall be capable of being bent without fracture to the angle specified earlier in this specification. It should be bent round a former having a radius of 25 mm.

iii) Non-destructive Tests

The following non-destructive tests at Cross-sections decided by the Employer shall be carried out to ensure that the castings are in every aspect sound, free from cracks, hot tears, shrinkage cavities and other defects.

a) Ultrasonic flaw detector test as per IS 3664 for checking the thickness of the castings and to detect the defects in the casting

b) Magnetic particle test

c) Ringing test

The Employer shall indicate the location to be examined on the casting and the stage of manufacture at which such examinations are to be made. The technique, inspection and interpretation of results shall be laid down and agreed between the Employer and the Contractor before the manufacture is commenced.

iv) Test by chemical analysis

Chemical analysis test shall be conducted to ascertain the percentages of sulphur and phosphorous content in the material of which the casting is going to be made. The Contractor shall supply a certificate of chemical analysis of such cast when required to do so by the Employer.

The Employer shall have the option to take the test sample and subject it to complete analysis by a metallurgist appointed by the Employer at the cost of the Contractor.

v) Testing facilities

The Contractor shall supply the casting required for testing free of charge and shall at his own cost furnish and prepare the necessary test pieces and supply labour and appliances for conducting all tests at his own premises in accordance with this specification.

If such facilities are not available at the place of manufacture for conducting the prescribed tests, the Contractor shall bear the cost of transportation for the test pieces or casting and for carrying out the tests at a place approved by the Employer.

vi) Test Certificate & Acceptance Criteria

The Contractor shall supply a test certificate giving the results of all tests mentioned in this specification, batch-wise, stating that the material complies with requirements as specified by the Employer.

vii) Re-test

If any of the test piece fails to pass any of the mechanical tests specified under tensile test and bend test, two further samples which represent that particular casting or castings shall

be selected and tested in the same manner. The Contractor shall have the option, if he so desires, to re-heat-treat (not more than twice) the casting before the two further samples are accepted. Should either of these tests fails, the casting represented shall be liable for rejection.

4.24.3.12 Bolts, Nuts and Washers

All anchor bolts, nuts and washers shall be of stainless steel conforming to AISI 304 or equivalent.

4.24.3.13 Fixing Details

The Contractor shall submit the detailed fixing arrangements of the bollard to the deck with full details of bolt etc. to the Employer for his approval.

The Contractor shall submit the following documents and certificates at suitable time for the approval of Employer

- Drawing showing the complete details of cast steel bollard.
- Drawing showing the fixing arrangements of bollard in the deck of the berth.
- All relevant test certificates.

4.24.4 Ladders

Ladders shall be provided on the berth face either in grooves without protruding outside the berth face or providing fender bars on either side of the ladder if it is protruding outside the berth face. Design & location of these shall be planned in such a way that shall not interfere with the ship's mooring operations.

Steel safety ladders shall be provided with a spacing maximum of 30(thirty) meters. These shall extend to a depth of 1 (one) meter below the lowest water level.

Unless specified otherwise the ladders shall be fabricated from mild steel and shall be coated with 300 micron DFT mastic epoxy paint of approved make and as per approved procedure against corrosion. The ladders shall be fixed with resin anchors using stainless steel bolts and nuts to AISI 316 or equivalent. Ladders shall be subject to inspection and approval by the Employer.

All permanently embedded parts in concrete shall be Stainless steel (SS-316) or equivalent, and remaining part shall be MS.

4.24.5 Rubbing Strip

Rubbing strip shall be of Stainless Steel (S.S) considering better performance, minimum maintenance and longer life.

4.24.6 Edge Angles

Edge angles shall be provided at the edges of the berth. All edge angles shall confirm to IS 808 with minimum size of ISA 50x50x6 mm. Edge angles shall be hot dip galvanised to minimum 75 micron in an approved method. MS Lugs shall be as welded as per approved method & instructions of Engineer-In-Charge.

4.24.7 Drain Holes

Drainage Spouts:

On deck 110mm diameter and 625mm longs PVC drainage spouts for every 100m^2 area shall be provided.

Drainage spout in rail trench having 50mm dia. and 1000mm long PVC pipe shall be provided as per drawing and as per specifications etc. to complete.

All PVC pipes shall confirm to IS 4985, class 3.

4.24.8 Mooring Rings

Mooring rings at suitable locations on jetty face shall be made from 20 mm dia stainless steel to AISI 304 or equivalent with an outer diameter of 150 mm. Suitable eyebolts of stainless steel to AISI 304 or equivalent shall be used with the mooring rings for fixing to the berth face.

4.24.9 Expansion Joints

Expansion joints provided at suitable distances should cater for movements in both longitudinal and lateral directions. Expansion joints shall confirm to IRC SP: 69

The Contractor shall provide all labour, supervision, materials, equipment and tools to carry out the work to the approval of The Employer. Instruction of manufacturer of the approved material shall be followed while preparing expansion joints. The Mill Test Certificate (MTC) of the materials shall be reviewed & thickness shall be complying requirements as Specified below.

i. Joints shall be provided to accommodate expansion and/or contraction in accordance to IS 2572 and as per GFC drawing. Joints shall be designed as to be built in as work proceeds and not to be cut into completed work.

ii. The boards shall be saw-cut to required sizes & not broken manually. The concrete surface being covered up by the Boards shall be clean & free of any dust, diet, loose particles, or any other material that may cause damage to the joint.

iii. The edges of the board shall be cut out such that the groove for applying sealant is formed in the required dimensions.

iv. Approved polysulphide sealant shall be applied in process recommended by the Manufacturer. Wherever applicable backing rods as recommended by Manufacturer shall be provided behind sealants. The backing rods also shall be of approved material. Closed cell polyethylene rod, or any other as recommended by Manufacturer shall be used for the purpose.

v. If slab seal types of expansion joints are specified then Contractor shall submit the manufacturing QAP of the material & obtain approval of The Employer in advance. Elastomeric materials of the slab seal shall generally conform to IRC- 83 (Part-II) & shall be manufactured as per approved QAP.

vi. Slab seal expansion joints shall be fixed in approved methods as recommended by the manufactures & as instructed by The Employer. Contractor shall arrange to have the expansion joint materials inspected at source if required by The Employer. The materials shall be supplied only after inspection at source by The Employer representative.

Minimum Records to be maintained:-

- Material Test Reports
- Approved QAP & inspection reports (for Slab seal type joints)
- Checklist as applicable

4.24.10 Painting And Galvenization specification

Wherever applicable painting shall be as per following codes

ISO 12944, ISO 8501 to ISO 8504.Sand blasting as per ISO 4628 part-3, and with manufacture recommendations.
Wherever applicable Hot dip galvanization (HDG) shall be as per IS 2629

4.24.11 Information Technology Systems

4.24.11.1 IT Architecture

For Project Facilities the IT architecture will have the following components:

- Business systems for Terminal.
- TAS- Terminal Administrative System/ERP System.
- System Software – Operating Systems, Database.
- IT Infrastructure & Facility Management.
- Business Intelligence/ Data Warehousing.
- Networking –Wired & Wireless.
- Hardware Systems (Servers, Storage, Desktops/Laptops)
- ISP Connectivity
- Backup & Recovery systems
- BCP/DR.

5 SPECIFICATIONS – ELECTRICAL

5.1 ELECTRICAL EQUIPMENT

5.1.1 HT SWITCHGEAR

5.1.1.1 General

This specification covers the requirements of 11kV Switchgear complete with all accessories. Continuous current rating of the Switchgear shall be based on the name plate rating of the connected equipment with 20% margin, rounded off to the next higher standard rating. 11kV Switchgear shall be rated for short circuit withstand capacity to be verified based on the data from BSPHCL.

Busbars, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The inside cubicle temperature shall be considered as design ambient temperature for maximum continuous operation rating of the equipment. For breaker control, 110 V DC supply shall be considered.

Each breaker module shall be provided with multifunction numerical relay for protection. Switchgear shall be provided with separate earthing trucks for cable earthing and bus earthing. Since HT panel has only one feeder, hence Bus Coupler is not required.

5.1.1.2 Switchgear Construction

Switchgear shall be indoor, single front, single tier, metal-clad, floor mounted, fully draw-out with VCB breaker. Design and construction shall be such as to allow extension at either end. Switchgear cubicle shall be so sized as to permit closing of the front access door when the breaker is pulled out to Test position. The working zone shall be restricted within 750 mm to 1800 mm as from floor level.

Circuit breakers, instrument transformers, bus-bars, cable compartment, auxiliary control devices etc., shall be housed in separate compartments within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. The circuit breaker and bus voltage transformers shall be mounted on withdrawable trucks. In case breaker truck rolls out on telescopic rails suitable trolley shall be provided. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on a control cabinet built on the front of the cubicle.

The trucks shall have distinct ‘Service’, ‘Test’ and ‘Isolated’ positions. The switchgear assembly shall be designed to achieve IP54 degree of protection, with the truck in any position ‘Service’, ‘Test’ and ‘Isolated’ and all doors and covers closed. Relaying and Metering compartment shall also have degree of protection IP54.

Enclosure shall be constructed with rolled steel sections / sheets of not less than 2mm. The switchgear shall be cooled by natural airflow. Forced cooling shall not be accepted. The Breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Breaker compartment doors shall have locking facility.

5.1.1.3 Bus and Bus Taps

Main buses and connections shall be of high conductivity aluminium, sized for specified current ratings with maximum temperature limited to 90°C. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2. The busbars shall be designed for a short circuit rating of 50kA for 1 sec. All bus connections shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with plain and spring

washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals. Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current.

Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchboard and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. The busbar chamber shall be provided with inter panel barrier with epoxy case seal-off bushings which the buses shall pass through so as to prevent fire from one panel to another.

5.1.1.4 Circuit Breaker

Circuit breaker shall be triple pole, single throw Sulphur Hexaflouride (SF_6) or Vacuum Circuit breaker. It shall be restrike free, trip free type. Breakers shall be suitable for switching transformers at any load. Rated operating duty shall be O-3min-CO-3min-CO. Short circuit withstand/interrupting capacity shall be 4026.3kA. Circuit breaker shall have communication facility for communicating with the PLC.

Circuit breakers shall be draw-out type, having SERVICE, TEST and DISCONNECTED positions with mechanical positive indication for each position. Operating mechanism shall be stored energy type. Circuit breakers of identical rating shall be physically and electrically interchangeable.

Each breaker feeder shall be provided with the following:

- An anti-pumping relay.
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator (to show whether the breaker / contactor is ‘ON’ or ‘OFF’ in the service, test and disconnected positions)
- Closing coil (100% continuous rated)
- Shunt trip (100% continuous rated)
- Manual trip push button
- Operation counter,
- Locking facility to prevent breaker/contactor from being closed when it is open.
- Pressure relief device
- Safety shutters for power contacts
- Inter-pole insulators
- SF6 gas pressure low alarm/trip relay (In case of SF6 type Switchgear)
- Auxiliary Signaling contacts

For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. SF_6 breakers shall be provided with SF_6 density / pressure switch with separate trip, alarm and blocking contacts.

Robust fail-safe mechanical and electrical interlocks shall be provided to prevent the following situations:

- Move the breaker unit from the service or disconnected position while the unit is closed.
- Move the breaker from the disconnected position to the service position while the earthing switch is closed.
- Close the earthing switch when the breaker unit is in service position or between the service and disconnected position.
- The operation of the circuit breaker while the truck is not properly installed in the service, test or disconnected position.

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The shunt trip coil shall operate satisfactorily at all values of control supply voltage between 70 and 110 percent of the rated voltage. For breakers spring charging motor shall be provided with overcurrent protection. Motor windings shall be provided with class B insulation or better.

Circuit breaker shall not produce any harmful over-voltage during switching off induction motors. Surge protective devices to limit over voltage shall be included in the scope of supply for all motor feeders.

5.1.1.5 Current Transformer (CT)

CTs shall be mounted on the switchgear stationary parts. CT secondary current shall be 1A. For metering separate core shall be provided. Core balance CT shall be provided for all the outgoing feeders. Accuracy class of the current transformer shall be:-

a. Class PS/ 5P20 for differential relaying and REF protection (Based on type of relay)

b. Class 5P20 for other relaying

c. Class 0.5 and ISF < 5 for metering

d. Class 0.2S for Energy Accounting & Audit meters

For metering separate core shall be provided. Core balance CT and associated relay combination shall be such as to ensure a pick up sensitivity of 10 A primary ground fault current for all the outgoing feeders. Facilities for easy shorting and grounding the terminals shall be provided at the terminal block. All terminal blocks shall be of stud type with marking strip.

5.1.1.6 Voltage Transformer

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 0.5. Voltage Transformer mounted on breaker carriage is not acceptable. Rated secondary voltage shall be 110V. Accuracy class for metering core shall be 0.5, protection core shall be 3P and 0.2 for energy accounting & audit meters. High voltage windings of voltage transformer shall be protected by current limiting fuses. Fuse failure relay shall be provided on the secondary side of all voltage transformers to monitor failure of fuses.

The following over voltage factor shall be considered for PT.

- 120% for continuous duty.
- 150% for 30 sec (for 415V solidly grounded system)

High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Low voltage MCB's, sized to prevent overload, shall be installed in all ungrounded secondary leads. MCB's shall be suitably provided with auxiliary contacts. MCB's auxiliary contacts connected suitably through relay shall be provided on the secondary side of all voltage transformers to monitor failure or trip of MCB's. The relay shall initiate alarm and block the tripping etc. which shall operate in case of VT MCB trip or failure.

5.1.1.7 Relays

Numerical multifunction relays shall be provided for all feeders. Numerical relay shall have trip circuit supervision. All protective relays shall be of draw-out type, suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle. Relays shall have lock-out facility with manual reset. Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. Under voltage relays shall be provided in the bus PT circuit.

Relays shall be rated for operation on 110V VT secondary voltage and 1A CT secondary current. The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer. DC isolation switch for each feeder shall be provided with backup HRC fuse. Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.

Incomers and Outgoing transformer feeders shall have the following minimum protection relays.

- Numerical protection relay having Instantaneous over current protection (50) on all the three phases, IDMT Over current protection (51) on all the three phases, Instantaneous earth fault protection (50N)
- Instantaneous Ground fault protection through CBCT (50G)
- Backup earth fault protection connected to Transformer neutral CT (51N)
- Latched Lock out relay (86).
- Trip circuit supervision relay (95)
- DC Fail relay (80F)
- REF protection relay (For Transformers 2MVA & above)

Self-reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication (52X) of the following:

- Transformer winding temperature indicator alarm and trip contacts.
- Transformer pressure relief trip contacts.

Bus Coupler (Tie) feeders shall have the minimum following protection relays.

- Latched Lock out relay (86).
- Trip circuit supervision relay (95)

- DC Fail relay (80F)

Motor feeders shall have Numerical motor protection relay having as a minimum following protections.

- Instantaneous earth fault protection through CBCT (50 N).
- Latched Lock out relay (86).
- Under voltage protection
- Trip circuit supervision relay

Bus PT shall have the following protections.

- Under & Over voltage relay
- MCB trip or failure relay
- No voltage relay

5.1.1.8 Control Switches

Circuit breaker control switches shall be 3-position spring return to `neutral' from both close and trip positions. They shall have `Pistol Grip' handle.

Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall generally have four positions, three for reading three phase currents and the fourth as off position. The voltmeter selector switch shall measure phase to phase voltages. The contacts shall be of silver plated, air break type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

5.1.1.9 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application. Bulbs and lamp covers shall be easily replaceable from the front of the cubicles. Low Voltage Glow Prevention (LVGP) feature shall be provided for indicating lamps. The colour of indication lamps shall be as follows:

- GREEN : Breaker Open
- RED : Breaker Closed
- AMBER : Auto trip & all Alarm conditions
- BLUE : Spring Charged
- WHITE : For all healthy conditions (e.g. Trip coil healthy & Control supply healthy).

For each breaker feeder, Panel indication lamps shall be provided as follows:

- Breaker Open
- Breaker Closed
- Auto trip
- Motor Spring Charged
- Trip coil healthy

- Control supply healthy
- Breaker in service position
- Breaker in Test position
- Lockout relay healthy
- SF6 Gas Pressure Low (Alarm)
- SF6 Gas Pressure Low (Trip)
- Any other indication, as required

For incomer and Bus, indicating lamps for R, Y, B phase shall be provided.

5.1.1.10 Meters

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level. All digital meters shall be with RS485 communication port. For incomers following Meters and transducers shall be provided:

- Ammeter
- Voltmeter
- Current transducer on three phases
- Voltage transducer on three phases
- Multifunction meter with digital display and communication port for kW, kVAR, kWH and power factor measurement.

For outgoing transformer feeders following Meters and transducers shall be provided:

- Ammeter
- Current transducer on one phase
- Multifunction meter with digital display and communication port for kW, kVAR, kWH measurement.

For outgoing motor feeders following Meters and transducers shall be provided:

- Ammeter on one phase
- Current transducer on one phase
- Hour run meter

For Bus PT following Meters and transducers shall be provided:

- Voltmeter
- Voltage transducer on three phase

All the transducers shall have dual output of 4-20 mA range. For motor feeders, it shall be 4-20-24 mA to measure starting current also.

5.1.1.11 Secondary Wiring

The Switchgear shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and inter locking schemes. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks. Wiring shall be done with flexible, 1100V grade, PVC insulated switchboard wires with stranded copper conductors of 2.5mm² for current circuits and 1.5 mm² for voltage circuits. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per Contractor's wiring Diagrams. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals. All external cable terminations shall be accessible while the breaker is in service position.

5.1.1.12 Terminal Blocks

Terminal blocks shall be 1100V grade box-clamp type with marking strips. CT shorting links, Drop link type terminals shall be provided for CT secondary leads. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

5.1.1.13 Cable Termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection. All provision and accessories shall be furnished for termination and connection of cables, including removable gland plates, cables supports and crimp type tinned copper lugs, brass compression glands with tapered washer and terminal blocks.

5.1.1.14 Name Plates

Name plates of approved design shall be furnished at each cubicle and at each instruments & device mounted on or inside the cubicle. The material shall be lamicoid or approved equal, 3 mm thick with white letter on black back ground. The material shall be held by self-tapping screws. Nameplate size shall be minimum 20 X 75 mm for instrument device and 40 X 150 mm for panels. Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

5.1.1.15 Space Heaters and Plug Sockets

Each cubicle shall be provided with thermostat controlled space heaters and cubicle lamp with door switch suitable for operation from 240 V ,single phase AC supply and 5A, 3 pin plug socket. The space heater shall be located at the bottom of each switchgear compartment. Cubicle heater, Motor heater, Plug/socket circuits shall have individual MCB units. In addition, motor feeder cubicle shall be wired-up for feeding the motor space heater through suitable rated breaker auxiliary NC Contact and/or contactor.

5.1.1.16 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.1.17 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.2 TRANSFORMERS

This specification covers the requirements of 11/0.433 KV distribution dry type transformers complete with all accessories. The Cast resin dry type transformers shall be capable of operating continuously at its rated output without exceeding the temperature limits specified.

The transformers shall be suitable for connection to the system having short circuit level and short circuit duration as specified. The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults. Calculation shall be submitted along with the offer to prove that thermal as well as mechanical withstand capacity of the transformer is as per Indian Standards in the event of short circuit to the specified duration. Transformers shall be designed to withstand the thermal and dynamic stresses due to Short circuit at the terminals for 5 seconds duration with respect to fault level specified.

The impedance of the transformer shall not be less than as stated in Indian Standard at a reference temperature of $75^{O}C$. The transformers shall be capable of delivering the rated output at any particular tap without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that particular tap.
- Frequency variation of $\pm$3% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage. The noise level at rated voltage and frequency shall be as per NEMA-TR1 standard.

The transformers shall be suitable for over-fluxing (due to combined effect of voltage & frequency) up to 10% on any tapping without injurious heating at full load condition. The maximum flux density in any part of core and yoke under such condition shall not exceed 1.9 Tesla.

Generally, the Transformer shall have total efficiency not less than 98% at full load condition. Transformer shall be fitted with diagram and rating plates. The diagram plate shall show the winding connections and tapings in tabulated form.

Salient parameters of the transformers are as follows:

- Nominal system voltage (HV / LV) : 11/0.433K V
- Vector group : Dyn11
- Temp rise in winding by resistance method: 60°C over 45°C ambient
- Parallel operation of transformer : Yes, only momentary
- Short circuit withstand duration : 2 seconds
- 11kV System fault level : 26.3kA for 1 sec
- 415V System fault level : 50kA for 1 sec

5.1.2.1 Windings

Transformers shall be connected as specified in design requirements. Winding shall comprise of high conductivity copper conductors completely impregnated and cast under vacuum in epoxy resin, fully insulated (with glass fibre reinforced epoxy insulation of very good electrical and mechanical quality), and shall be suitable for the highest system voltage. Winding shall be concentrically wound on the core, and shall be braced to withstand shocks, which may occur through rough handling during transport, switching and other transient condition during service, and also to reduce to a minimum the damage arising from stresses due to an internal fault. All windings shall be subjected to vacuum drying.

5.1.2.2 Core

Cores shall be built from best quality, low loss, cold-rolled, grain oriented electrical steel laminations conforming to relevant Indian Standard. All core sheets shall be to reduce the core loss to a minimum. The flux density in core shall not exceed 1.6 Tesla under over voltage conditions and to this effect calculations shall be submitted. Maximum current density shall not exceed 2.5A per sq.mm. All joints shall be interleaved and the core shall be securely clamped so as to ensure that the noise level and the vibration are maintained at a minimum. All clamps shall be adequately insulated. The complete core shall be coated with special resin as a protection against corrosion.

5.1.2.3 Temperature Indicators

For measuring hot spot temperature in the winding, 150 mm dia dial type winding temperature indicator (WTI) with adjustable potential free alarm and trip contacts, maximum reading pointer and resetting device shall be provided. Temperature sensing element shall be complete with image coil, bushing CT etc. Accuracy class of WTI shall be +/- 2°C or better.

5.1.2.4 Bushings

All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. Bushings located inside cable boxes / bus-duct flanges can be epoxy-moulded types. Bushing CTs shall be provided as per system requirement. Secondary leads of CTs shall be wired upto-marshalling box. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover. Current transformers shall be cast resin type with Class E or better insulation.

5.1.2.5 Terminal Arrangement

Type of terminal connection shall be by Cables on both HV & LV side. The cable box shall be suitable for the working pressure of cable with which it is associated and shall have adequate clearances for the specified voltage and cable termination kits. For cable termination, terminals of transformer shall be brought out through side wall mounted bushings to a detachable cable box with disconnect link. The cable box shall be self-supporting, weather proof, air filled type complete with all hardware such as undrilled gland plates, etc.

The design of the box shall be such as to preclude the access of water to the box. An adequate space shall be provided within the box so that the cable cores may be formed into the lugs without undue bending or stress on the lugs, and adequate clearance shall be preserved between live metal and frame such that the electrical pressure tests specified in Indian Standard are satisfied. Flexible links shall be provided between transformer terminals and cable lugs. Cable box shall have IP 55 degree of protection.

5.1.2.6 Marshalling Box

Marshalling box shall be sheet steel enclosed with IP 55 degree of protection alarm & trip contacts of all the fittings & accessories and secondary leads of CTs shall be wired up to marshalling box. Cable gland plate shall be of removable type. The marshalling box shall have isolating switch & MCB for incoming power supply. Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided. The marshalling box shall have 10% additional set of control terminals.

5.1.2.7 Grounding

Two grounding pads, located on the opposite sides shall be provided for connection of station ground mat / overall earthing for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers. Two ground terminals each shall be provided on marshalling box & cable box. For neutral connection, two ground copper conductors of specified size shall be provided, supported on pin insulators (provided on tank) from neutral bushing to the bottom of the tank for connection to station ground.

5.1.2.8 Off Circuit Tap Changer

Off Circuit tap changers shall be provided on HV winding with +/- 10% range of taps in steps of 2.5%. The tap changing shall be affected by an external 3 phase gang operated tap change switch. The operating handle shall be padlocked at any position. The mechanism shall be provided with a mechanical tap position indicator, mechanical stop to prevent over cranking of mechanism etc. A warning plate indicating 'For de-energised operation only' shall be fitted.

5.1.2.9 Wiring and Terminal Blocks

All control cabinets, marshalling boxes, etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All spare contacts of switches, relays and other devices shall be wired upto the terminal block.

Wiring shall be done with flexible 1100V grade HR PVC cables with stranded copper conductor of minimum size 2.5 sq.mm. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawings. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

Terminal blocks shall be of 1100 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting. Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided. All devices and terminal blocks within the panel shall have identification numbers as per schematic diagram.

5.1.2.10 Nameplate

Each transformer shall be provided with a nameplate of weather-resistance material fitted in a visible position showing all the 'information and additional information' as per IS: 1117.

5.1.2.11 Fittings & Accessories

Each transformer shall be supplied with the following as a minimum:

- Two nos. Stainless steel Rating & Diagram (Hindi & English), terminal marking and danger plates.

- 3 earth terminals per transformer, each suitable for earth conductors of size 2 numbers 75x10mm GI strip for earthing of the body of the transformer and its enclosure.
- Lifting lugs for complete transformer and Core-coil assembly
- 6 numbers PT100 RTDs with Winding temperature indicator (WTI) display
- 4 nos. Jacking Pads
- 4 nos. Bi-directional Rollers / flanged wheels with stopper arrangement to lock transformer in required position
- 4 nos.Cover lifting eyes
- Marshalling box
- Cable box
- 1 no. off circuit tap changer
- 3 nos. HV Bushings with terminal connectors
- 3 nos. LV Bushings with terminal connectors
- 1 no. LV Neutral Bushings with terminal connectors
- Platform mounting channel
- 1 set LV Neutral Bushing CTs
- 2 nos. Inspection covers
- 2 nos. supports for HV cable box
- 1 Lot Interconnecting cables

5.1.2.12 Testing and Inspection

Transformer and all its fittings should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Transformer and all its fittings shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.2.13 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.3 LT SWITCHGEAR

This specification covers the requirements of 415 V Power Control Centre, Motor Control Centre, Main Lighting Distribution Boards, AC Distribution Boards, Lighting / Welding Distribution Boards, Starters, Local Push button stations etc. complete with all accessories. The switchgear and its components shall be designed for design ambient temperature of 45^{O}C. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Auto/Manual/Planned Changeover scheme with synchronizing feature for various incomers and bus couplers shall be provided in Power Control Centre (PCC) / Motor Control Centre (MCC) for interlocking of Incomer breaker with upstream breaker. Incomer, bus-coupler & Outgoing breakers shall also be controlled from PLC (only provision to be provided since there is no PLC envisaged at this stage) in addition to Local operation from the panel.

- Short circuit withstands rating of the switchgear shall be as given in the attached SLD.

- 415V normal system shall be solidly grounded. 110V DC system shall be ungrounded.

Busbar, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The continuous current rating of the bus bars, incomers, bus couplers of the MCC shall be the maximum load on the bus due to all the running auxiliaries during any operating condition plus 20% margin rounded off to the next higher standard rating. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2 and for Copper busbars as 1.25 Amps/mm^2.

Close & Open control of all the motors in PCC/MCC shall be provided in PLC (provision only at this stage) in addition to Local Push Button Station (in the field) and from the panel. Local operation of circuit breakers shall be possible in "Test" position. Remote indications / alarms shall be provided in the PLC (provision only at this stage). The control / interlock schemes for various types of feeders shall commensurate with their application.

PCC & MCC shall be of draw out type for all the modules including breaker modules/ Starter module/SFU module. ***MCCs are conventional type with numerical relays and all equipment shall be with RS-485 communication facility****. Distribution boards shall be of fixed type.*

All PCC/MCC/DB shall be single front type. 220V control supply shall be derived from 415/220V control supply transformer located in respective module. 240V AC space heater supply provision shall be provided for motors rated above 30 kW. For breaker operated feeders, control supply voltage shall be 110V DC.

At least 20% of feeder modules covering the range of motors used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.

All motors shall have direct on line starter. 90kW and above capacity motors shall be fed from ACBs. Less than 90kW capacity motors shall be fed by MCCBs and contactors. However, the duty of the drive/application, i.e. high impact loading, etc. to be considered as criteria for selecting ACB operated motors even for rating < 90kW. Wherever applicable, priority shall be given to the use of Motor Protection Circuit Breaker (MPCB) with Contactor.

Operating height of the handles/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

For PCC changeover shall be provided. If there is an under voltage (dipped to 30-40% voltage) on any one of the buses, sensed through under voltage relays, the respective incomer breaker shall trip automatically and the bus coupler shall close, if the voltage is available on the other bus section, thereby establishing voltage at 415V motor terminals before motor reaches standstill condition. The auto changeover shall be blocked if any of the following condition exists:

- Any of the involved breaker is in the test or withdrawn position.
- Source voltage is not available.
- Source breaker is tripped due to bus fault.

No release is acceptable for Breaker feeders. Only CT operated relays shall be provided for protection. MCCB, Contactor and overload relay shall meet type-2 co-ordination as per applicable standard.

5.1.3.1 DESIGN AND CONSTRUCTION

PCC / MCC

415 V panels shall be of metal enclosed, indoor, floor-mounted, free-standing type. Switchboard frames and load bearing members shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. Doors and covers shall also be of CRCA sheet steel of thickness not less than 1.6 mm. Thickness of gland plates shall not be less than 3.0 mm for sheet steel & 4.0mm for non-magnetic material. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with IP54 degree of protection. Outdoor switchgear enclosures should have minimum IP55 degree of protection for covered area and IP65 for uncovered area.

All switchboards shall be of uniform height not exceeding 2450 mm. Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers. Module size of switchboards shall not be less than 200mm. Cable entry for PCCs/MCCs/DBs shall be from bottom.

Switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

- Main busbar compartment:
- Switchgear / feeder compartment
- Cable alley
- Auxiliary busbar compartment
- Control compartment for relays for ACB feeder

The feeder compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure. All circuit-breaker panels shall be of single-front type. All single-front switchboards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with “DANGER” labels.

All 415 V circuit-breaker modules and MCC modules shall be of fully draw-out type having distinct `Service’ and `Test’ positions. The equipment pertaining to a draw-out type module shall be mounted on a fully withdrawable chassis, which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle / rollers and guides shall be provided for smooth movement of the chassis.

Main Lighting Distribution Board (MLDB) / Power Distribution Board (PDB)

MLDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. MLDBs shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv)cabling chamber. MLDBs shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation.

PDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. PDB shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv) Dry type transformer (v) cabling chamber. PDB shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation. PDB shall be provided with 415/415V, 3 phase dry type transformer of suitable capacity to obtain 3 phase, 4 wire system and to limit the fault level to 35KA. The capacity of the transformer shall be decided such that there is at least 20% margin over the total lighting load. Fault level required for PDB bus & incomer shall be 35kA.

MLDB & ACDB shall be provided with one TPN MCCB for incomer feeder and required number of 3phase outgoing feeders with TPN MCB's and two Nos. Spare feeders. CT operated ammeters and Voltmeter and indicating lamps shall be provided for incomers.

Lighting Distribution Boards (LDB)/Power Distribution Board (PDB)/Control Distribution Board (CDB)

Distribution boards shall be metal enclosed, fixed type, single front, and compartmentalized construction. The Distribution board frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6 mm. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP54 for indoor and IP55 for outdoor installation. The handle of incoming switch shall be mounted on the door of the board, with padlocking facility in both 'ON' and 'OFF' positions. Cable entry facilities shall be provided with removable gland plates of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

For lighting circuits, Lighting Distribution Boards (LDBs) shall be provided and for welding receptacle circuits, separate Power Distribution Boards (PDBs) shall be provided. LDBs shall be provided with one 63 Amp TPN MCB for incomer and required number of 20 Amp SPN outgoing feeders with MCBs with neutral links for each circuit distributed over three phases. Maximum lighting load on any one circuit shall be restricted to 1500 watts.

PDBs shall be provided with one 63 Amp TPN MCB with ELCB for incomer and required number of 32 Amp TPN outgoing feeders with MCBs with neutral links for each circuit distributed over three phases. Maximum welding receptacle load on any one circuit shall be restricted to 2000 watts.

5.1.3.2 Air Circuit Breakers

Air Circuit breakers shall be (three pole for motor feeders and TPN for other feeders), air break, horizontal draw-out type, and shall have fault making and breaking capacities as specified. These shall be microprocessor based with RS 485 communication facility. There shall be "SERVICE", "TEST" and "ISOLATED" positions for the breakers. In "Test" position, circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "ISOLATED" position. It shall be possible to close the door in "Test" position.

Each breaker feeder shall be provided with the following as a minimum:

- Electrical anti-pumping feature
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator
- Closing coil
- Shunt trip coil
- Manual trip push button
- Operation counter
- Phase barriers
- Shutter assembly

- Door interlock kit

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The closing coil & shunt trip coil shall be rated for 100% continuous duty. One Open-Close-Open operation of the circuit breaker shall be possible after failure of power supply to motor. For breakers spring charging motor shall be provided with over current protection. Motor windings shall be provided with class B insulation or better. The shunt trip coil shall operate satisfactorily, all the values of control supply voltage between 70 and 110 percent of the rated voltage.

Circuit breaker of the same type and ampere rating shall be wired alike and shall be mechanically interchangeable.

All Air Circuit Breakers shall be provided with the following interlocks:

- Movement of a circuit breaker between “SERVICE” and “TEST” position shall not be possible unless it is in open position.
- Closing of a circuit breaker shall not be possible unless it is in “SERVICE” position, “TEST” position or in “ISOLATED” position.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. ACBs shall have CT operated relays for over current and earth fault protection.

5.1.3.3 Moulded Case Circuit Breaker (MCCB)

MCCB shall in general conform to IS: 13947 Part-2. MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. These shall be microprocessor based with RS 485 communication facility. The setting of the thermal release shall be adjustable from 75% to 100% of the rated current. The MCCB shall have breaking capacity not less than 50kA. MCCBs used for incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

5.1.3.4 Control and Selector Switches

Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions. Circuit breaker control switches shall have three positions and shall be spring return to “NEUTRAL” from “CLOSE” and “TRIP” positions and shall have pistol grip handles. Circuit breaker selector switches shall have three stay put positions marked `Test’, `Local’ and `Remote’, respectively. They shall have black spade handles. Selector switches for starter modules shall have ‘Test’, ‘Local’, ‘Remote’ positions as specified. Ammeter and voltmeter selector switches shall have four stay put positions with adequate number of contacts for 3-phase 4-wire system. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary.

5.1.3.5 Contactors

Motor starter contactors shall be air break, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced. Direct-on-line contactors shall be of utilization category AC3. Reversing starters

shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. The contactor shall operate satisfactorily from 85% to 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

5.1.3.6 Instrument Transformers

The CTs shall be mounted on the switchgear stationary parts. For metering separate core shall be provided. The CTs shall be of cast resin, bar primary type and of Class E or better insulation. CT secondary current shall be 1A. Accuracy class of Current Transformer shall be Class 5P20 for relaying and Class 0.5 and ISF < 5 for metering. CTs for current rating less than 50A shall be 'Wound primary' type and above 50A shall be 'Bar primary' type.

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 1.0. The bus VTs shall be housed in a separate compartment. All VTs shall have readily accessible fuse and MCBs on primary and secondary sides respectively.

5.1.3.7 Indicating Instruments

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All such meters shall be fed through suitable Current transformers for motors rated 10kW & above. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level.

5.1.3.8 Push Buttons

Push-buttons shall be of spring return, push-to-actuate type. Where specified push buttons shall be stay put type. Their contacts shall be rated to make, continuously carry and break 10A at 500 V AC . All push-buttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All push-buttons shall be provided with integral escutcheon plates marked with its function. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided.

The colour of the button shall be as follows:

- Green for motor START, breaker CLOSE, valve / damper OPEN /CLOSE commands.
- Red for motor TRIP, breaker OPEN.
- Black for all annunciator functions, overloads reset and miscellaneous commands.

5.1.3.9 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type .The lamps shall have escutcheon plates marked with its function, wherever necessary. All indicating lamps shall be rated for continuous operation at 85% to 110% of their rated voltage. Low Voltage Glow Prevention (LVGP) feature shall be provided for indication lamps. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

- Red for motor ON, breaker CLOSE.
- Green for motor OFF, breaker OPEN.
- Blue for Service
- White for Test, Spring Charged, Spring Discharged, Lockout Relay Healthy

- Amber for auto trip

5.1.3.10 Control Supply and Space Heater Supply

The breaker operated PCC/MCC shall receive two nos. 110V DC feeder for the control supply and distribute to each panel. Auto changeover arrangement shall be envisaged between two supplies. Each panel shall receive control supply through bus wires and shall be tapped off through switch & fuse provided in the respective panel. It shall be possible to isolate any panel without disturbing the power supply to other panels. Each sub circuit shall have separate fuse. An under voltage relay to monitor control supply shall be provided. A contact of the relay shall be wired to the terminal for external use. `Control Supply Failed' indication shall be provided.

Each starter module of MCC shall derive 220V AC control supply through control supply transformer. The control transformers shall be of insulation class `B' or better. The sizing of control transformers shall be carried out by the contractor considering the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment including remote auxiliary relays and lamps in the circuit.

For space heater circuits of motor rated more than 30kW and also for panel space heater, 240V AC supply shall be provided by tapping from the incomer before the main isolating switch/breaker. Necessary switch and MCB to isolate and distribute the supply to each panel shall be provided. For motor feeders, circuit for motor space heater shall be wired through NC contact of breaker/contactor and MCB.

Each panel of PCC/MCC/DB shall be equipped with the following as required:

- Thermostatically controlled space heater(s)
- Illumination lamp with door switch
- 5A 3pin socket with MCB protection

5.1.3.11 Wiring

All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables. All internal wiring shall be carried out with 1100 V grade, HR PVC/ XLPE insulated single core, copper conductor of minimum 2.5 sq.mm for CT circuits and 1.5 sq.mm for other circuits. All internal wiring terminations shall be made with solder less crimping type tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs. Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire. Number 6 and 9 shall not be used for wire identification.

Control terminal blocks shall be of 1100 Volts grade, rated for 10 Amps and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT & VT secondary leads shall be provided with test links & isolating facilities. CT secondary leads shall be provided with short circuiting & earthing facilities. In all the panels at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.

5.1.3.12 Power Cable Termination

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC / XLPE insulated, armoured and FRLS PVC sheathed cables. All power cable terminals shall be of stud type and the power

cable lugs shall be of tinned copper solderless crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

5.1.3.13 Nameplates and Labels

PCCs, MCCs, Distribution Boards, local push-button stations and local motor starters shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Suitable stenciled paint mark shall be provided inside the panel/module for identification of all equipment, in addition to the plastic sticker labels, if provided. These labels shall be positioned so as to be clearly visible and shall have the device number, as mentioned in the module wiring drawings. Caution name plate “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

5.1.3.14 Busbars and Insulators

Each PCC/MCC & DB shall be provided with three phase and neutral busbars. DC distribution boards shall have two busbars. All busbars and jumper connections shall be of high conductivity aluminium alloy for PCC/MCC and Copper for DB of adequate size. The cross-section of the busbars shall be uniform throughout the length of switchboard. Interleaving of PCC busbar arrangement shall be envisaged. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fibre glass moulded insulators. All busbar joints shall be provided with high tensile steel bolts, belleville/ spring washers and nuts. All copper to aluminium joints shall be provided with suitable bi-metallic washers. All busbars shall have HRPVC sleeves and colour coded.

Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble free connection. Suitable bimetallic connectors shall be used for dissimilar metal connections. The continuous rating of the main busbars shall be same as that of the incomer breaker, and busbar shall carry this continuous current without exceeding the temperature of 90º C. For silver plated joints, temperature shall not exceed 105°C. All horizontal and vertical busbar joints shall be covered by insulating shrouds.

5.1.3.15 Earthing

A copper/ Aluminium earthing bus of adequate size shall be provided at the bottom and shall extend throughout the length of switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar. The earth bus shall be sized to withstand specified short circuit current. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e., ‘Service’, ‘Test’ and ‘Isolated’ as well as throughout the intermediate travel.

All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. All hinged doors shall be earthed through flexible earthing braid. VT and CT secondary neutral point earthing shall be at one place only on the terminal block. All metallic cases of relays, instruments and other panel mounted equipment shall be effectively bonded to the earth bus by independent stranded copper wires of size not less than 2.5 sq.mm.

5.1.3.16 Local Push Button Stations

The local push buttons stations shall be with FRP enclosure, suitable for outdoor mounting on wall or steel structures. The local push button stations shall be dust and vermin proof and shall have a degree of protection of IP55 as per IS: 13947 Part-1. Local push button stations shall comprise Start/Stop push buttons as per drive control philosophy. Emergency stop Push-buttons shall be stay put/Latching type, requiring master key for de-latching.

5.1.3.17 Following shall be provided for each breaker feeders

- Electrical anti pumping feature (94)
- Hand reset High speed lockout relay (86)
- Trip circuit supervision relay (95)
- Aux relay for breaker contact multiplication (52X)
- Aux relays as required for contact multiplication
- Indicating lamps for ON, OFF, Auto trip, spring charged, Trip circuit healthy, DC supply fail etc.
- Breaker control switch
- Local / Remote / Test selector switch
- Test Terminal blocks

ACB incoming feeders for PCC from transformers shall be provided with the following as a minimum.

- TPN Air Circuit Breaker
- Current transformers for metering & protection
- Digital Ammeter & Ammeter transducer
- Fuse/MCBs for control circuits
- Voltage transformers, Digital voltmeter & voltage transducer
- Under voltage relay with timer
- Microprocessor based Multi-function meter with communication facility
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

ACB Bus coupler for PCC from transformers shall be provided with the following as a minimum:

- TPN air circuit breaker
- Current transformer for protection & metering
- Fuse/MCBs for control circuits
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

Unidirectional motor feeders rated less than 10 kW shall be provided with the following as a minimum:

- Triple pole motor protection circuit breaker (MPCB)
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type

- MCB for control circuit
- Interposing relays

Unidirectional motor feeders rated 10kW and up to 30kW shall be provided with the following as a minimum.

- Triple pole MPCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Current transformer for metering
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated above 30kW and less than 125kW shall be provided with the following as a minimum.

- Triple pole MCCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons
- Indicating lamps LED cluster type
- Numerical Motor protection relay
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transformer for metering
- Current transducer
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated 125 kW and above shall be provided with the following as a minimum.

- Triple pole Air Circuit Breaker
- Current Transformer for metering & Protection
- Numerical Motor protection relay
- Fuse/MCBs for control circuit
- Indicating lamps LED cluster type
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transducer

- Digital Ammeter
- Interposing relay

Bi-directional Motor feeders shall be provided with the following as a minimum. (Not applicable for Integral Actuators)

- Triple pole MCCB
- Triple pole mechanically interlocked, open / close contactors
- Auxiliary contactors
- Local/Remote/Test switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons.
- Indicating lamps LED cluster type
- MCB for space heater circuit
- MCB for control circuit
- Interposing relays

5.1.3.18 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.3.19 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.4 110V DC SYSTEM

This specification covers the requirements of 110V DC Batteries, Chargers and DC Distribution Board. The function of the 110V DC Power Supply System is to provide the normal source of power to the 110V DC loads, such as Control Supply to Switchgears / Panels. The duty cycle imposed on the battery shall include the following:

- Continuous loads (indicating lights, continuously energized coils, Control Panels, Relays)
- Momentary loads (switchgear operation (Trip coil/Closing coil), which exist for a period of less than 1 min period)

110 VDC Power Supply System shall be operated as an ungrounded system; that is, the negative terminal or ground reference terminal is not connected to the station ground grid. A DC ground monitoring system on the DC systems shall be provided and any DC ground fault shall be alarmed.

Batteries shall be sized in accordance with IEEE-485. The battery shall be sized with a 10% design margin and an ageing factor of 1.25. 110V DC Power Supply System shall consist of 2x100% 110V batteries, 2x100% 110V battery chargers cum DC Distribution Board. End Cell Voltage of Lead Acid Plate battery shall be considered as 1.85 V / Cell and for Nickel cadmium battery as 1.14V / Cell. During Normal operating condition, batteries shall be supplied from two (2) 100 percent battery charger. The chargers are supplied power from PCC/ MCC. The battery charger shall supply power to 110V DC loads and, at the same time, shall continuously float charge fully charged batteries. Both the chargers shall have dedicated

incoming AC supply from MCC/PCC. During Emergency operation the battery shall supply the DC load when there is a loss of all auxiliary AC power supplies and/or a loss of power from the battery chargers. Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency condition when AC supply is lost.

The Charger shall be float cum boost type suitable for float charging both the batteries and supply load simultaneously. Chargers shall boost charge fully discharged batteries in 12 hours. Design margin of minimum 20% shall be considered in charger sizing for either mode of operation. Charger protections such as DC-O/V & U/V, AC U/V, E/F, S/C protection etc. shall be considered.

5.1.4.1 Construction of Battery

Lead Acid (Valve regulated) sealed maintenance free Plate type batteries shall be float charged at 2.15 to 2.20 Volts per cell and chargers shall also be capable of boost charging the associated DC battery up to 2.7 Volts per cell at the desired rate. Batteries shall be rated for 10 hour discharge rate (C10) as per manufacturer data. Containers shall be made of suitable glass fibre reinforced plastics or Polypropylene. Containers shall be robust, heat resistant, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.

Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminals shall be clearly marked. Each cell shall be separately supported on porcelain insulators fixed on to the racks with adequate clearance between adjacent cells. Breathers/Vent plugs etc. shall be provided for each cell. It shall be anti-splash type and having more than one exit hole to allow the gases to escape freely but prevent the acid spray from the battery. Lead coated copper inter-cell connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells, interconnections shall be fully insulated or have insulation shrouds/covers.

End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC/XLPE insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 60 minute discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Anti-corrosive gel shall be applied at the Battery terminals.

Wooden racks shall be provided for batteries for multi-tier installation. These racks shall be made of good quality first class seasoned teak wood. They shall be free standing type mounted on porcelain insulators. Numbering tags, resistant to acid for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Following accessories shall be provided with batteries.

- Syringe type Hydrometer : 2 Nos per Battery
- Thermometer with specific gravity correction scale : 2 Nos per Battery

- Cell testing voltmeter 3-0-3 volts : 2 Nos per Battery
- Acid resistant funnel : 2 Nos per Battery
- Acid resistant jug. : 2 Nos per Battery
- Rubber apron and gloves : 2 sets per Battery
- Spanners : 2 sets per Battery
- Wall mounted teak wood rack for above items : 2 Nos per Battery

Following maintenance spares shall be provided as a minimum

- Inter cell connectors : 10 Nos.
- Inter row connectors : 2 Nos.
- Battery stand insulators : 2 Nos
- Cell insulators : 2 Nos
- Nuts, bolts & washers : 10 pieces each
- Vent plugs : 10 Nos.
- Spare dry cell : 4 Nos.

Fuse box for each battery shall be provided in the battery room and shall comprise the following:

- DP Fuse Switch unit
- HRC Fuses with striker pin & aux contact for remote alarm
- FRP enclosure.

Discharge resistor made of punched stainless steel grid enclosed in sheet steel enclosure shall be provided for discharge testing of Battery.

5.1.4.2 Construction of Battery Charger cum DCDB

During float charging, charger shall feed the respective DC Distribution board and as well as float charge its own batteries and maintain a DC voltage that shall pass the minimum current through the cells to keep them charged without overcharging. In case of mains failure to charger or charger failure, battery shall supply the full load. While boost charging of respective battery, DCDB shall be isolated from the Charger and shall be fed from other Charger. Each Battery charger should meet the Trickle requirement of both banks (under emergency) and boost requirement of each bank.

During boost charging, battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100 % of the rated output current for boost charging mode. During boost charging, the Boost charger shall recharge the completely discharged battery to full capacity in 12 hours.

When on automatic control mode during float charging, the charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency variation of + 3/-5%, a combined voltage and frequency (absolute sum) variation of 10 % and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Battery chargers

shall have a selector switch for selecting the battery charging mode i.e. whether float or boost charging.

All Battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. The chargers shall be self-regulating, natural air cooled, static type provided with suitable double wound transformer, full wave thyristor type rectifiers, filter circuits, DC & AC Switchgear. Chargers shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP54.

Rectifier transformer shall be continuously rated, dry type, class F insulation, epoxy resin impregnated, Air Natural (AN) cooling and with adequate number of taps. The rating of rectifier transformers shall correspond to the rating of the associated rectifier assembly.

All the Charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and MCB's shall be provided separately for each of the above fittings. Space heaters "ON" indication to be provided. Two separate grounding pads shall be provided.

Locking facilities shall be for locking float / boost selector switch in the float position only. Digital type Window annunciator shall be provided for alarm annunciation with acknowledge, test & reset push buttons and a buzzer for the following conditions:

- SCR fuse fail
- Battery / DC system under voltage
- DC system over voltage
- DC over load
- Output fuse blown
- AC supply fail
- AC under voltage
- Battery earth fault
- Filter fuse failure
- Battery on Float / Boost
- Charger fail/Battery on discharge
- Any other annunciation, as required

Remote alarm contacts for hooking up to PLC shall be provided. For each charger, current & voltage transducer shall be provided for remote monitoring of DC voltage and Current at PLC.

Protection features, indications, meters and alarms shall be provided for each charger. Protection features shall include the following as minimum.

- Overload Protection
- Phase failure protection
- Voltage unbalance protection
- Fuse failure protections for SCR and filter circuit

Suitable potential free contacts for remote indication of above abnormal conditions shall be provided. However the requirements / design shall be firmed up during the detailed engineering stage.

5.1.4.3 Testing and Inspection

Battery & Charger and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Battery & Charger shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.4.4 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.5 Power and Control Cables

Power cables shall be sized to satisfy the following Criteria:

- Short circuit withstand capacity for applicable fault current and duration.
- Full load current carrying capacity under installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
- Permissible voltage drop limits under steady state/transient state as applicable.

Power cables shall withstand fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

- Outgoing cables from 11kV Switchboards : 40 kA for 0.16 sec.
- Incoming cables to 415V PCC (Breaker operated): 50 kA for 1 sec.
- Incoming cables to 415V MCC (Breaker operated): 50 kA for 0.5 sec.
- Incoming cables to 415V MCC/DB (MCB protected): Fuse cut-off current for 10m.sec
- Cables from 415 V MCC to Motors : 50 kA for 0.16 sec ACB operated
- Feeders from MCC/DB (MCB protected) : Fuse cut-off current for 10m.sec

To maintain voltage at motor terminals / equipment end with in desirable limit, it is proposed to limit the voltage drop in the cables within the following limits:

- Steady state Voltage drop (Continuous running condition): 2.5%
- Transient state voltage drop (During Motor Starting): 10 %

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The minimum size of LV power cable shall be of 2.5 Sq.mm for Copper. Power cables shall have copper conductor for sizes up to 10 sq.mm. For higher sizes, aluminium conductor shall be provided. The minimum size of control cable shall be of 1.5 Sq.mm copper. For CT/VT circuits, minimum 2.5 sq.mm copper cable shall be provided. Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

Power cables shall be XLPE insulated. Control cables shall be PVC insulated. PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath. For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire as per applicable IS. Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%
- Smoke density of not more than 60%

The cables shall meet flammability test as per IEEE-383. All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

5.1.5.1 Construction

HT cables

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-II. 11kV cables shall be suitable for unearthed system. The conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process. The metallic screen of each core shall consist of copper tape with minimum overlap of 20% copper screen which shall be capable of carrying the system earth fault current for 2 seconds. Outer sheath shall be FRLS PVC.

LV Power cables

LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-I.

Control cables

Control cables shall be of 1.1 kV grade, multicore, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed stranded copper conductor conforming to IS:1554 Part-I. Up to 5 cores it shall be colour coded and above 5 cores shall be numbered.

Trailing cables (if applicable)

Trailing cables / Flexible cables shall be rubber insulated with copper conductor as per applicable standards. The minimum size of LV power cable shall be 4 Sq.mm for Copper.

5.1.5.2 Cable identification system

In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.

- Cable size and voltage grade.
- Word `FRLS' at every 5 metre.
- Sequential marking of length of the cable in meters at every one metre.

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

5.1.5.3 Cable Drums

Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by `U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

5.1.5.4 Testing and Inspection

Cables offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests, Acceptance tests and all special tests for FRLS properties shall be carried out for all the cables as per applicable standards. The sample shall be drawn at the rate of one per type and size for every lot offered for inspection.

5.1.5.5 Special Tests

The following tests as applicable to FRLS sheathed cables shall be conducted as type tests on each size of each lot.

a. Oxygen index test

b. Temperature index test

c. Acid gas generation during fire

d. Smoke generation test under fire

e. Swedish chimney test for class F3 as per SS : 424-14-75

f. Under fire conditions for bunched cables as per IEEE std. 383 / 74

5.1.5.6 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.6 Lighting System

This specification covers the requirements of Illumination system.

The lighting system includes

- 100% Normal AC lighting
- 20% High Mast Lighting and other Lightings 100% on DG set
- Emergency lighting through battery backed Portable lamps in selected areas of the plant during plant emergency conditions.

Normal AC Lighting shall be energised from 3-phase, 4-wire, 415 V main lighting distribution board. These MLDBs shall feed Lighting Distribution Boards (LDB) for each individual area. ***Indoor Dry type lighting transformers of voltage ratio 1:1 shall be provided without enclosure*** *for reducing fault level in MLDB.*

The single phase voltage level considered for lighting system & fixtures shall be optimally arrived to achieve energy efficiency without sacrifice in the illumination level. Lighting transformer tap range & tap step to be designed accordingly.

Emergency lighting shall be provided in specific areas such as switchgear rooms, areas near local panels, staircases and other strategic areas during AC supply failure. Emergency lighting shall normally be “off,” and upon loss of normal AC supply, emergency lights shall be turned “on” in auto mode. Emergency lighting units with integral batteries shall be used. Emergency lighting unit shall provide light for one hour when the normal power source is lost. Each emergency light unit shall be provided with battery, battery charger and one number 5 watt LED lamps. Exit light fixtures shall be LED and provided in all the Building at exit doors.

LED lamps shall be used as light sources in the lighting system. Fixtures considered shall be energy efficient type with low loss & low harmonics (less than 10%) and with higher lumen / watt.

Emergency lighting luminaries shall be supplied to ensure a safe exit in case of power failure. Emergency light shall be with dimming and SOS feature. Each shall be connected to the 240 V supply system and shall automatically switch to the battery in case of power supply failure. The battery shall be able to supply power to the lamps for a minimum of 1.0 hour.

Enclosure of all fittings shall be of weather & dust-proof construction and consist of cast aluminium body able to withstand direct hosting. AC lighting fixtures and accessories shall be suitable for operation on 240 V AC, 50 Hz supply with supply voltage variation of $\pm$ 10%, frequency variation of +3% to –5% and combined voltage and frequency variation of absolute sum of 10%.

Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries surface dirt and room surface dirt, etc.

- Air conditioned areas : 0.8
- Non-Air conditioned areas : 0.7
- Dust prone outdoor Areas : 0.6

Suitable number of 63 ampere, 3 phase, 415 volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and minimum 2 numbers on each floor in all the buildings.

20A, 240V, Single phase convenience receptacle with switch shall be provided in all the rooms. The convenience outlets shall be spaced to provide access to any point with a 15 meter extension cord. Receptacles shall be served from an earth leakage circuit breaker (ELCB).

Welding sockets shall be fed from ACDB / PDB. Number of receptacles per circuit shall not be more than 2. Each welding receptacle unit shall have dedicated MCB installed adjacent to the receptacle with IP55 type enclosure.

The light fixtures shall be circuited so that adjacent fixtures are connected to alternate phases of a 3-phase circuit. Auto-timed switching may be considered with manual bypass mode for indoor lighting system. The lighting for enclosed areas within the buildings shall be manually switched ‘on’ and ‘off’ at local light switches near personnel entrance doors. Wall mounted switches shall be provided at the entrance to battery room and equipment/office rooms.

Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Outdoor lighting shall have auto/manual mode of operation. Provision shall be made to bypass the photoelectric controller and timer.

Switches shall be sized maximum of 80 percent of the light switch ampere rating with enclosures suitable for the location in which they are installed. Load on each lighting circuit and single phase receptacle circuit shall be limited to 2000 W.

For areas illuminated by more than one circuit, the adjacent circuit shall be fed from different phase. Load balance on all the 3 phases to be envisaged for lighting as well as 1-ph power distribution circuit. Wiring for indoor lighting installation shall be carried with PVC insulated wire with following sizes laid in conduit.

- Lighting Panel to lighting Fixtures: 2.5 sq.mm copper
- Switch box to lighting Fixtures: 2.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

For Area lighting, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed Copper conductor cables shall be provided.

Wiring for lighting circuits of Normal AC system and DC system shall run in separate conduits. Wiring for Lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits. Two different phase circuits shall not be laid in the same conduit.

All conduits shall be surface mounted in general. In Office rooms & Control rooms conduit shall be concealed type. Conduit fill criteria shall be 40%. Conduits should have the minimum number of bends in their run with pull boxes at suitable locations. Conduits shall be sloped & drained to avoid water accumulation & draining into the equipment at its end. Conduits shall be galvanized steel except in corrosive areas, where it shall be epoxy painted.

Lighting and Welding Transformer shall be suitably accommodated along with other equipments in the final equipment layout prepared by EPC contractor.

Receptacles

3 phase Industrial type welding receptacles shall be rated for 415V, 63 Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65.

1 phase Industrial type receptacles shall be rated for 240V, 20A Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65. 1 phase receptacles with switches shall be provided at each emergency portable lamp fittings.

All receptacles shall be provided with matching plug-tops. All hardware shall be of Stainless steel type only including the mesh of well glass luminaries, nut, bolts, washers, etc.

5.1.7 High Mast Lighting System

5.1.7.1 General

High Mast at the proposed locations in the plant area shall have adequate height to achieve the required illumination. Top level of high-mast foundations shall be as per the approval from the engineer-in-charge. All High Mast of similar height shall be identical in construction to allow possible future relocation of High Masts within the area. A High Mast Switchboard is required to be installed at the base of each High Mast. The High Masts are expected to be fabricated out of steel.

The High Mast shall be designed for the number of light fittings determined by the Lighting Design based on the average 30 lux (with minimum 20 lux) of illumination plus two additional fittings to allow for possible future modifications/expansion. The High Mast shall be designed for the worst sail area resulting from the most adverse configuration. The High Mast shall be designed to withstand loads from fabrication, handling, erection, and for the dynamic loading outlined below.

5.1.7.2 Design Criteria

The lighting design shall be in accordance with IS:3646. The selection of lamps and luminaire types shall be based on high efficiency, good glare control and illuminance level required. Luminaires, mast and brackets shall be selected to suit the harsh environmental conditions specified. Luminaires shall have high power factor (0.85 or higher) control gear. Any apparatus, appliance or material or services which may be necessary to make the system complete and perfect in all respects even if not particularly specified shall be furnished, without any additional expense to the Employer. Details not usually shown or specified, but necessary for the proper installation and operation of the work shall be included.

5.1.7.3 Fittings

Lighting fittings selected shall be LED type. Lighting fittings shall be full cut off type to prevent stray light above 90 deg. Light fixtures shall be provided with Power factor correction capacitor to achieve high power factor.

5.1.7.4 Light Switching Philosophy

Each High Mast shall have following separate circuits.

Security Lighting Circuit, controlling 20% of the light fittings on High Mast. This circuit shall be controlled by a photoelectric cell located in substation so that the security lights turn on automatically depending on preset solar radiation level. Manual over ride facility shall also be available in the switchboard located at the base of the high mast. Main Lighting Circuit No. 1, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

Main Lighting Circuit No. 2, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

5.1.7.5 Location of High Masts

High Mast locations shall be as shown in the Drawing **I-525/KGT/224** attached with these specifications. High Mast number, height and location are indicative, final details as per the detailed design shall be submitted to the Employer for approval. It is anticipated that the high mast positions as shown on the Drawings will provide sufficient coverage to obtain the specified illumination.

5.1.7.6 Detailed Lighting Plan

Detailed lighting distribution plans of the entire area along with Lux level plot plan shall be provided for approval of the Employer by the successful contractor.

5.1.7.7 High Mast Head Frames

Each High Mast shall be fitted with a head frame, which shall be capable of being lowered and raised by means of a winch or other similar mechanical mechanism. The winch shall be able to be operated by use of a power tool. Each High Mast shall be provided with internal power tool complete with drive motor and drive assembly of suitable rating. The power for the drive motor of power tool shall be from the respective high mast switchboard. The head frame shall be of durable steel construction fitted with light and gear fixings and junction box. It shall be in single piece for maximum strength. The head frame shall also act as an

electrical conduit with cable holes protected by grommets. The head frame shall incorporate arrangements to prevent damage to the galvanizing of the High Mast.

5.1.7.8 Mechanical Arrangement – Lowering and Raising Headframe (Ring) System

For installation and maintenance purpose, it is required that the headframe (ring) be able to be raised or lowered using a winch or approved lowering device to the base of the High Mast. The steel wire rope supporting the headframe shall be kept in balance and horizontal at all times. A device, suitably protected from corrosion, shall be incorporated to ensure that the tension rope cannot accidentally or manually be released without a service tool.

5.1.7.9 Top Pulley Assembly – Lowering and Raising Headframe (Ring) System

The pulleys for the lowering and raising of the headframe system shall be of non-corrodible material and shall run on self-lubricating bearings with stainless steel axles. They shall be of sufficient diameter so as to enable multicore flexible cables to be used. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. It is intended that there will be 2 cables from the High Mast Distribution Board at the base of the High Mast to the junction box on the headframe. Individual cables will then run from the junction box to each light fitting. This cabling arrangement will need to be considered in the design.

The pulleys shall be housed in a chassis integral with a sleeve which slips over the top of the High Mast and is secured axially and in azimuth. Guides and stops shall be provided for locking the headframe and an anchor point shall be securely welded to the assembly to receive the safety maintenance equipment. The complete chassis assembly shall be hot dip galvanized after fabrication. The pulley assembly shall consist of safety brakes capable of immediate stopping of the raising and lowering device even in the extreme case of hoisting cables breaking.

The pulley assembly shall be protected by a galvanized steel/aluminium or other approved weatherproof cover.

5.1.7.10 Winches – Lowering and Raising Headframe System

Winches shall be completely self-sustaining without the need for brakes, springs or clutches which require adjustment and shall be designed to be installed or removed through the door opening. Termination of the winch ropes shall not involve distortion or twisting of the rope structure. A minimum of four turns of the rope shall remain on the drum when the lantern carriage is fully lowered. Winch drums shall be grooved to ensure a tidy rope lay. A test certificate issued by an independent test house shall be supplied with each winch. The capacity and operating speed of the winch shall be clearly marked on each winch on an indelible label together with the Specification of the recommended lubricant. Each winch shall be supplied with a fitted canvas cover.

5.1.7.11 Lightning Protection and Earthing System of High Mast

Each high mast shall be provided with lightning protection and earthing system which shall be installed and tested as per BS:6651, BS:7430 and TR7, ILE, UK, and IS:2309, IS: 3043 & IEEE:80-2000.

5.1.7.12 Openings

Any openings in High Mast for feeding of cables/stainless steel rope in and out of the High Mast require coverings/cappings so as to prevent the intrusion of rain water into the High Mast.

5.1.7.13 Dynamic Loading

All High Masts shall be designed for maximum reaction arising from basic wind speed of 180 km/hr and factors K1, K2, K3 as per IS:875 (Part III) for design wind speed. The minimum design life shall be 30 years. High Masts shall be designed in accordance with relevant Indian earthquake standard. The design shall be such that wind excited oscillations are damped as much as possible and an adequate allowance shall be made for the stress due to these oscillations. The method of damping shall be stated. Full calculations of the forces involved shall be submitted for approval. The analysis shall show the resultant loadings, deflection and stresses in all three principal axes at a minimum of 500 mm increments over the total length of the High Mast. In addition, High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

5.1.7.14 High Mast Construction

All steel used in the construction of the High Mast, including welding shall comply with relevant Indian or British standards for Structural Steelwork. High Mast shall be constructed from mild steel plates, of grade and thickness as determined in the design. The minimum steel plate thickness shall be 6 mm. An appropriate corrosion allowance shall be used in the design. High mast shall be cut and folded to form a polygonal/circular section. Adjoining sections of the High Mast shall be joined by taper slip fit jointing. No site welded joints will be permitted.

All High Masts shall have a close fitting weatherproof door at the base with hinges and a heavy duty lock. The lighting distribution board shall be placed inside the High Mast base at this location. The size of the door is expected to be approximately 1.00 m x 0.50 m in size but may vary according to each design. The bottom of the door shall be located at a height of 0.50 m from the underside of the base plate of the High Mast. The door opening shall be reinforced where required to prevent buckling. The reinforcement being designed to suit the width of the door opening under the designing loading specified. Ten (10) sets of keys shall be provided for each type of lock.

The baseplate shall be free from laminations and the welded connection to the High Mast shall fully develop the strength of the section. In addition supplementary gussets shall be provided between bolt holes. On the completion of fabrication, all High Masts and headframes shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

5.1.7.15 Foundations

The design and layout of each type of High Mast shall be furnished. The design shall be based on the foundations not resting on bedrock & shall be carried to a depth of at least 2.0 m below final grade. Settlement shall not exceed 25 mm, unless specified otherwise and the structural arrangement and design shall be such as to withstand such settlements. The top level of the concrete pedestal shall be as per the approval of the engineer-in-charge. The footings for the High Mast including holding down anchor bolts with nuts and washers shall be supplied and installed under this contract.

5.1.7.16 Wire Ropes

Wire rope system shall be suitable for maintaining the lighting fixtures/control gear from the ground level in spite of crash barriers around the mast. Wire ropes shall be flexible stainless steel type. Thimbles and terminals shall be of compatible material. Ropes with hemp cores will not be permitted. In the event of failure of one rope the other rope shall hold the lantern carriage.

5.1.7.17 Materials

All materials shall comply with relevant Indian or British Standards. All steel conduits, metal work, angle iron brackets, suspension rods etc. shall be hot dipped galvanized to a minimum thickness of 100 microns. Where galvanizing has been damaged this shall be repaired with an approved two pack zinc rich epoxy finish.

5.1.7.18 Luminaires

Luminaires shall be standard industrial type suitable for high pressure sodium vapour SON-T lamps of 2x400 W/1x1000 W/1x400 W and shall have not less than 55000 lumens per 400 W lamp. Lighting fixture shall be waterproof, dust proof and suitable for highly corrosive atmosphere. It shall be manufactured with die-cast aluminium, MBV treated reflector, electronically brightened and anodized, IP 54 degree of protection and confirm to relevant IS specifications. The lamp shall be easily replaced from rear without disturbing the aiming position. It shall be provided with stainless steel toggles, heat resistant & toughened glass cover. Hardware used to install the fittings, control gearboxes and for other purposes shall be of stainless steel. The luminaires shall be tested as per Indian Standard and shall be suitable for installation on high mast.

5.1.7.19 Aviation Light

LED type aviation light shall be provided at each mast.

5.1.7.20 Power Tools

This is a geared motor with suitable torque limiter, industrial duty type. The motor is mounted on MS hot-dip galvanized plate inside the mast with a possibility of adjusting its position. However, the adjustment shall be so arranged that it cannot be altered easily during normal use of tool at site.

5.1.7.21 High Mast Switch Boards (HMSB)

These boards shall be free standing pad mounted type. The boards shall be designed for the number of circuits as required. The boards shall include miniature circuit breakers/ELCB, Contactor, ON-OFF Control Switch and all other required accessories as required. The cubicle shall be designed for mounting over RCC pad of 300 mm thickness minimum and shall be capable of withstanding the vibrations normally experienced due to vehicular traffic. The top cover of the enclosure shall have slope to prevent accumulation of rainwater. A gland plate shall be provided at the bottom of the switchboard. An incandescent lamp shall be provided inside the switchboard, with door switches on both doors, so as to switch 'ON' when the door is open.

The circuit wiring shall be as required. System control panel shall be fabricated out of CRCA sheets – 2 mm thick for structural components and 1.6 mm thick for covers and doors & hot dip galvanized after fabrication. HMSB shall be fabricated out of stainless steel of grade 316 to prevent corrosion. HMSB shall be sized to allow for heat generated and design includes for dissipation of heat and shall be IP 65 degree of protection plus canopy, whereas system

control panel shall have minimum IP54 degree of protection. Each board/panel shall be provided with hinged door with gaskets.

230V AC auxiliary and control supply aluminium bus bars shall be provided through control transformer of adequate capacity in HMSB. The Board/Panel shall have earth bus bar running through the whole length of the board. All equipment mounted in the board shall be directly connected to this earth bus.

5.1.7.22 Wiring

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be PVC insulated stranded, copper conductor of 2.5 sq.mm cross section. Each control wire shall be identified at both ends with wire designations in accordance with the relevant Indian Standards. All wire terminals shall be with compression or clamp type connectors. Wires shall not be spliced or tapped between terminal points. Designation ferrules shall be interlocking type with designation engraved with indelible ink. Not more than two wires shall be connected to one terminal. Power and control wires shall be neatly bunched, separately and adequately supported so as to prevent sagging and strain on termination. Terminal blocks for power and control wiring shall be provided with adequate clearances.

5.1.7.23 Component Specification of HMSB

a) Contactors

Contactors for AC shall be 3 pole air-break electromagnetic type suitable for making and breaking locked rotor current of the motor which is equal to around six (6) times the full load current. Contactor shall have minimum 2 Nos. auxiliary contacts. Minimum rating of power contactor shall be 16 Amps. Contactors shall be suitable for uninterrupted duty as per IS 2959 and utilization category shall be AC3 as per IS:4064. The contact material of the contactors shall have anti-weld properties. Insulation class of the operating coils shall be class E or better. Operating coils of AC contactors shall be suitable for 240 V $\pm$10%, 50 $\pm$3% Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

b) Photo Electric Switch

A photo electric cell/switch operating on 240 Volt AC shall be provided for automatic group control switching operation based on solar radiation levels.

c) Auxiliary Contactors

The auxiliary contactors and no volt relay will be provided as per circuit requirement. The contact rating shall be 10 Amp for AC. The auxiliary contactors shall have at least 8 contacts in contact combinations as per the requirement.

d) Control Terminal Blocks

Control terminal blocks shall be of 650 volts grade, rated for 10 amps and in one piece moulding. It shall be complete with insulation barriers, clip on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. At least 20% spare terminals for connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm2 size stranded copper conductors. All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks. Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links. Self-

aligning, spring loaded, silver plated, sliding contacts for proven design shall be provided as control terminals for withdrawable / drawout modules. Detachable plug and socket type control terminals shall also be acceptable.

e) Indicating Lamps

The indicating lamps shall be panel mounting large industrial cluster LED type and shall be interchangeable. Indicating lamps shall be with translucent lamp covers. The lamp covers shall be mounted flush on the front panel door and shall be replaceable from the front of the cubicle.

5.1.7.24 Installation of Light Fittings

Mounting height of center-line of the various lighting equipment from FFL/Working platforms or finished grade level shall be as noted below unless otherwise specified in corresponding lighting layout drawings:

- Lighting panels/control gear boxes : 1500 mm
- Switch boxes : 1500 mm
- Receptacle boxes (Indoor) : 500 mm
- Receptacle boxes (Outdoor) : 1000 mm
- JB on poles/Masts : 750 mm

Lighting fixtures to be mounted on ceiling/platforms having considerable vibrations which can cause damage to the fixtures shall be suitably supported with rubber pads to limit vibrations in the fixtures. Where conduit wiring is adopted, an earth continuity conductor of 12 SWG galvanized steel wire shall be provided for earthing the lighting fixtures, switch boxes, etc. The earthing conductors shall be run along the entire length of the conduits and shall be securely connected and terminated at the junction boxes/control gear boxes/lighting panels. The earth connection shall be properly secured with bolts, nuts and washers. For outdoor lighting installations, an earth continuity conductor of atleast 25 x 3 mm galvanized steel flat shall be used for earthing the lighting masts/poles.

While designing the lighting circuit, the cables shall be sized such that the farthest loop from the supply receives no less than 95% of its nominal voltage, in addition it must be assumed that all the light fittings are energized while this design calculation is made. LED lights should be chosen & located carefully where they illuminate rotating shafts, so as to avoid stroboscopic effect. Fittings made from Aluminium and its alloys should be avoided because the oxide that invariably forms after a time is considered as a potential source of sparks caused by mechanical impact. All fittings shall be installed at a safe height for maintenance & effective illumination. All lighting controls shall be from a non-hazardous area, using double pole, switches, the supply neutral should be switchable along with the phase.

5.1.7.25 Testing and Inspection

Equipment of Illumination system should be type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Equipment shall be subjected to routine tests as per applicable Indian Standard. Test reports shall be submitted for approval.

5.1.7.26 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.8 Cable Trays and Accessories

This specification covers the requirements of cable trays, support structures, cable laying, termination, earthing and lightning protection system. While finalizing Cable routing layouts, consideration shall be given to the requirements of Safety, Reliability and Convenience of cable laying and termination. Where duplicate drives/auxiliaries are provided for reliability, cable routing shall be segregated to the extent practically possible.

In cable trenches, distance between bottom most tier and bottom of trench shall be 150 mm and clearance from top most tray to top of trench cover shall be 400 mm. Distance between two tiers shall be minimum 250 mm. PCC flooring of built-up trenches shall be sloped in longitudinal and also in transverse direction for effective drainage system. Cables should not be laid directly in the trench floor. Cables trenches should be provided with strong & effective covers with water & fire proof sealing arrangement at trench entry & exit points.

Other than cable vault & cable trenches, Cable trays shall be laid in vertical formation to avoid dust accumulation. In cable spreader room a clear access passage of at-least 800 mm wide shall be provided along the cable ways. Wherever passage is through cable routes, a clear height of not less than 2.0 M shall be provided.

Cables of different voltages shall be laid in separate racks. Minimum distance of 250 mm shall be maintained along the routes between various types of cables. In case of horizontal formation, the highest voltage cables shall be laid in the top most position in the tray stack followed by other grades as follows in the descending order.

- 11 kV Power cables (Top Tier)
- 1.1kV Power cables (Below HT Tier)
- Electrical Control Cables (Below LT Tier)
- Instrumentation/Signal cables (Bottom most tier)

On cable trays all the multicore power cables can be laid in touching formation. Single core cables shall be laid in trefoil formation with the spacing equal to twice the diameter of the cable. Control cables shall be laid in not more than two layers. Power & Control cables shall be laid on ladder type trays. Instrumentation & Signal cables shall be laid on perforated type trays. Cable trays shall be supported at an interval of 1500 mm approximately. Vertical runs shall be supported at an interval of 1000 mm approximately. Cable tray support system shall be site fabricated, welded and painted steel supports. Cable tray support system shall consist of ISMC channel as vertical support & ISA as horizontal arm. Horizontal arm is welded to the vertical support MS channel.

Cables shall be terminated using double compression cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass. Cable lugs for power and control cables shall be tinned copper solderless crimping type conforming to IS 8309. 11 kV cable terminations shall preferably be of heat shrinkable type kits.

Fire barriers/ Fire stops shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical Switchgear / Panels from Cable Vault. Fire barriers/ Fire stops shall provide a fire endurance rating of at least 2 hours. The fire sealing material shall be non-hygroscopic, mechanically steady, non-toxic and physically & chemically stable under fire conditions.

Fire barriers/ Fire stops shall be either of the following methods:

a) Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant

b) Mortar Sealing method comprising Mixing Mortar curing with water

5.1.8.1 Design and Construction of Cable Trays

Cable trays shall be ladder/perforated type as specified prefabricated made out of Fibre Reinforced Plastics (FRP) complete with matching fittings (like elbows, bends, reducers, tees, crosses, etc.), accessories (like side coupler plates, Tray cover etc.) and hardware (like bolts, nuts, washers, GI strap, hook etc.) as required. The size of the trays shall be selected on the basis of maximum 50% fill criteria. Cable trays shall be standard width of 150mm, 300mm, 450mm & 600mm. Thickness of side coupler plates shall be minimum 2.5mm and of tray covers shall be minimum 1.6mm. Cable Trough shall be required for branching out few cables from main cable route. These shall also be fabricated of FRP of minimum thickness 3mm. Troughs shall be of standard width of 50mm & 75mm and 25mm height.

5.1.8.2 Design and Construction of Conduits/Pipes, Fittings & Accessories

Conduits/pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.). The size of the conduit/pipe shall be selected on the basis of maximum 40% fill criteria. Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458. GI pipes shall be of medium duty as per IS: 1239.

Rigid steel conduits conforming to IS: 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint. Conduits shall be smooth from inside and outside. Fittings and accessories shall also be hot dip galvanized.

Flexible conduits where required, near equipment terminations, shall be made with bright, cold rolled, annealed and electro-galvanized mild steel strips. Flexible conduits shall be supplied with suitable end coupler nipple and check nut. In corrosive areas, epoxy coated conduits shall be provided.

5.1.8.3 Cabling Installation

The work shall be carried out in the best workman like manner in conformity with relevant specifications / code of practices of the Bureau of Indian Standards. In addition, work shall also confirm to the requirements of latest editions / amendments of the following:

- Indian Electricity Act and rules framed thereunder
- Fire Insurance Regulations
- Regulations laid by the office of the Chief Electrical Inspector to Government
- Any other regulations laid down by the local authorities

Support system shall be so designed that it is able to withstand weight of the cable trays, Weight of the cables, concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of at-least 1.5 shall be considered. Cable tray mounting structure shall be welded/bolted to the plate inserts or to steel structure and the type of welding shall be of fillet type of at least 6mm size.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on top most tier. The cable risers or vertical

raceways shall also be covered by cable tray covers upto 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

5.1.8.4 Testing and Inspection

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

5.1.8.5 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.9 415 V DIESEL GENERATOR SET

The output from the unit shall be 175KVA (at alternator output), 415 volts, 3 ph, 50 Hz, 0.8 power factor. DG set shall be required to operate as standby unit under the following environmental conditions:

- Ambient temperature: $45^{O}C$
- Relative humidity : Above 90%
- Altitude : Sea-level

5.1.9.1 Diesel Engine

The engine shall comply with the requirements of relevant BS 649/BS 5514. Engine shall be designed for maximum reliability ensuring uninterrupted operations. Engine shall be capable of delivering 10% overload for a period of one hour in any consecutive twelve (12) hour period. The values of rating, rotative speed and brake mean effective pressure (BMEP) for a specific engine design will not be accepted unless they are published as catalogue data.

Engine shall be heavy duty, industrial type four stroke delivering matching BHP at 1500 rpm, turbo charged radiator coded suitable for standby duty. Engine and auxiliary system shall be designed for safe start, stop and running on high speed diesel (HSD). Engine performance shall confirm to ISO:3046/BS:5574.

Engine Governor shall be electronic.

The set shall be capable of accepting at least 60% of rated load in a single step from an initial startup condition.

Filters of the replacement element type shall be provided on the engine for fuel oil, lubrication oil and air intake.

Engine Starting shall be 24 V DC battery system designed so that at least two separate attempts can be made, to prevent complete loss of starting capacity in one attempted engine start. Sizing of starting system should be in accordance with the engine manufacturer's recommendations, but in no case should the storage capacity be less than 30 seconds of cranking. An automatic static battery charger which possesses characteristics of "Zero-float" and positive charging shall be used. An engine-driven battery-charging generator is not acceptable. Batteries shall be maintained in a warm ($20^{O}F$ to $110^{O}F$) atmosphere to assist in quick starting. The battery system shall be of lead acid automotive type.

Flywheel Guards shall be provided as required.

An **engine control unit** free from vibrations comprising of the following devices with sensors (mounted at engine) shall be provided as minimum:

- Water temperature gauges for jacket water temperature
- Water pressure gauge
- Tachometer for engine speed
- Lubricating oil, pressure and temperature gauges
- Automatic shutdown and indication for low lubricating oil pressure, over crank, low coolant level, high cooling water temperature and engine over speed.

5.1.9.2 Engine Auxiliaries

5.1.9.3 Cooling System

Cooling system shall be radiator type. Anti-freeze liquids and corrosion inhibitor as recommended by engine manufacturer shall be used to obviate the danger of damage occurring from the use of incompatible or improper liquids or inhibitors.

5.1.9.4 Intake and Exhaust System

a) A residential type exhaust silencer of suitable size for exhaust run shall be provided complete with all support frames etc. to reduce engine exhaust noise. It should be kept as straight as possible.

b) Dry type air-inlet filter, exhaust manifold, mufflers shall be used. Type of filter selected shall be to fit the environmental conditions at the site.

c) Combustion air shall be taken directly from outside.

d) The air-intake and exhaust shall be so located as to preclude the contamination of fresh air with exhaust gases.

e) To dispose of the radiant heat given off by the exhaust pipe, sheet metal ductwork shall be supplied with 50 mm of space between the ductwork and the exhaust pipe.

5.1.9.5 Fuel Oil System

a) The fuel-injection system shall be complete with PT fuel pump, injectors, fuel filters and self-contained piping.

b) The system shall generally comprise of

- Day tank capacity for 10 hour running at 75% load.
- Pumps required for conveying fuel from day tank to engine. Critical pumps should be provided in sets (1 working + 1 standby)
- The day tank shall also act as a relief and by-pass tank for fuel oil that is circulated to the injectors whereupon any excess fuel is by-passed back to the day tank.

5.1.9.6 Fuel Filtering System

The primary filtering system shall be located at day tank inlet. In addition the engine shall have secondary filtering system. Both filters shall be capable of absorbing water.

5.1.9.7 Lubricating Oil System

The pressure lubrication system shall be used. The filter shall be of simplex type with paper element. The full flow lubricating oil filter can be mounted on the lubricating pump or remote mounted with flexible lines.

5.1.9.8 Piping and other Associated Connections

All piping, flexible connections, flange valves, seals, fittings etc. shall be supplied by the Contractor for all the associated auxiliaries of equipment.

5.1.9.9 Alternator

Alternator shall be air cooled, brushless, 3 phase, fan ventilated, synchronous type fitted with heavy duty, long life ball or roller bearing with forced lubrication or lubricant packed for approximately 4000 hours of running without attention. The alternator shall be manufactured in accordance with BS 2613 IEE-341 or as per relevant BIS, ISO, DIN, NEMA, standard. The unit shall be horizontally mounted.

Enclosure shall possess minimum IP23 degree of protection. Insulation throughout shall be class H, temperature rise by resistance. All windings shall be impregnated to allow operation in climatic conditions specified in this volume. The Alternator shall be provided with following minimum accessories:

- Resistance temperature detectors
- Bearing temperature detectors
- Space heaters.

The basic ratings of the Alternator shall be as follows:

a)	Rated voltage	:	415 Volts
b)	Speed	:	1500 rpm
c)	Rated power output:		As specified (Continuous rating)
d)	Frequency	:	50 Hz
e)	Number of phases	:	Three
f)	Power factor	:	0.8
g)	Type	:	Brushless, synchronous, self-excited self-regulated
h)	Neutral earthing	:	Solid grounding
i)	Voltage regulation	:	+1% of rated voltage from no load to full load at any power factor between 0.8 lagging and unity
j)	Type of cooling	:	Self cooled fan ventilated

5.1.9.10 Metering and AMF Control Panel

This is intended for operation of DG set in auto mode. The panel shall be sheet steel construction and arranged for free standing, floor mounting and bottom entry with front and rear access. The interior wiring of the cubicle shall be looped and clipped and all wire ends are to be clearly identified. Any printed circuit boards shall be tropicalized.

Following metering and protection devices as a minimum requirement shall be included in each panel:

A) Metering Instruments (Digital)

- Voltmeter
- Ammeter
- Frequency meter
- KW meter
- Battery voltmeter
- Power factor meter
- Hours run indicator
- KWH meter
- KVAR meter
- Excitation current ammeter
- Excitation voltmeter
- Engine Speed Indicator

B) Push Buttons

- Engine start PB
- Engine Stop PB
- Lamp Test PB
- Reset PB
- Emergency Trip PB

C) Indication Lamps (Cluster LED type)

- DG set on
- Load on DG set
- Set running
- Mains available
- Mains failure
- Start failure
- Generator over current
- Generator high voltage
- Generator low voltage
- Earth fault
- High engine speed
- Low engine speed
- Low fuel level
- High fuel level
- Charge failure
- Generator winding temperature high
- High bearing temp
- Low lubricating oil pressure
- High lubricating oil temperature
- Engine jacket water temperature high

- Engine jacket water pressure low
- Reverse power
- Low fuel oil pressure
- Rotor diode failure

D) Protective Relays

- IDMT relay (Over current and earth fault)
- Over voltage relay
- Under voltage relay
- Reverse power relay
- Field failure relay
- Differential relay
- Phase failure relay

E) Multi-function Meter with Transducer

- Voltage – Ph-to-Ph & Ph-to-N
- Current – line to neutral
- Power – kW, kVAH, kVAR (Avg. & Ph. wise)
- Energy – kWH, kVAH, kVARH
- Power Factor – Average & Ph. wise.
- System frequency
- Import & export kWH & kVARH.
- RS 485 MOD BUS

5.1.10 Telephone System (EPABX)

5.1.10.1 General

The design shall be in accordance with the basic requirements described in the Tender Document and the best current engineering practice, together with the following general design requirements. EPABX and Telephone instruments are in Contractors Scope as already defined in Clause No. 1.3.18.2, S.No. 23.

a) The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.

b) All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.

c) Care shall be taken so that materials and equipment are the standard Catalogued products of manufacturers regularly engaged in the manufacturer of such products and shall be of the latest standard designs that conform to the specification requirements. Design shall also be based on similar type of equipment supplied from one manufacturer, utilizing interchangeable parts, wherever practicable.

d) The design shall comply with relevant codes and regulations listed.

e) All apparatus, equipment and works shall be so designed that they provide satisfactory service and without any harmful effects for prolonged and continuous periods in the worst climatic conditions.

f) The reference design ambient temperature for all electrical equipment shall be taken as 45^{O}C and appropriate derating factors should be considered for equipment as applicable.

g) Suitable derating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.

h) Tentative number and location of the Telephone system is shall be decided during detailed engineering in consultation with the Employer.

5.1.10.2 Main EPABX

The proposed EPABX shall be 100% Non-Blocking, Electronic, ISDN native. The topology shall be totally distributed so as to support and configure the Remote Units flexibly as per the changing and evolving requirements on Optical Fiber as well as copper cable.

The system shall be based on High Speed, i3 CPU and with at least 2 GB RAM. It shall be equipped with Duplication of complete Control section (viz. CPU, Signaling circuits, Tone generators, Memory, Hard Disk – 1TB, RS232 ports, DTMF resources, conference circuits and other essential circuits) and common Power Supply & Ringer section in 100% Hot Standby mode. The system shall enable automatic changeover in case of failure in any of these without disrupting the existing calls in progress. The Operating system software shall be Unix based.

The system shall have RISC processor, RAM capacity of the system explicitly mentioned. It shall also specify the different control system elements duplicated in the offered system. EPABX system shall be equipped with Ethernet port (30/100 Base T) and shall have provision to connect a TCP/IP LAN for management and metering application, which shall facilitate system management from any LAN node without using modems.

It shall be equipped with storage devices to save the data, as well as software necessary for its operation. For security reasons, these devices shall be of Flash ROM type, easy to duplicate and shall not cause any disturbance to the system. The Contractor shall specify whether information concerning variable data (forwarding, screenings) is automatically saved in real time, so that if the system goes down and comes up for any reason it doesn't loose data integrity.

5.1.10.3 Trunk Interfaces

The EPABX shall have all the following types of Interfaces:

- Analogue Interface to PSTN lines
- Interface to Leased Lines
- Paging System Interface
- Interface to VSAT Equipment
- BR and PR interface to Public ISDN Network
- Digital Interface for DID
- IP FOR VoIP & Data transfer

5.1.10.4 Extensions

A) Analogue Extensions

The system shall be compatible with both Pulse & Tone Dialing Instruments.

Contractor shall clearly specify the DTMF receivers available on the system whether they are centralized or distributed, if they are centralized. Contractor to mention number of such receivers on each board. The number of DTMF Receivers shall be 50% of the ultimate capacity to handle peak traffic conditions. The Contractor shall specify the number of such boards equipped in the system offered.

B) Digital Extensions

The Digital phones shall have an Alphabetic Keyboard with "Dial by Name" facility from the central database of the PABX system and a user-friendly operation of the PBX internal services and of the services provided by the ISDN trunk. These terminals, as well as lower-range terminals shall be equipped with keys, which can be directly programmed by the user. The keys enable the user to change several functions (for example: call forwarding code + external number, etc.)- An option shall allow the number of keys on certain terminals to be extended. It is desired that all programming information on digital sets to be centralized and saved in the PBX to enable simple replacement.

The Contractor shall offer his range of digital terminals giving detailed specifications of their features:

- Voice sets
- Voice and data sets for ISDN & VoIP..

For each type of terminal, the Contractor shall specify the following characteristics:

- Type of terminal,
- Remote power supply or not,
- Maximum distance of connection on 0.5mm cable (min. 1000meters)
- Number of pairs necessary for the distribution,
- Capacity of data transmission,
- Interface for ISDN & VoIP,

The features, which have to be systematically accepted by digital terminals, are:

- Connection of VDU terminals
- Additional ISDN services
- IP services

The Digital telephone sets with Display panels and Dynamic Soft keys as a part of this display panel shall be quoted. These shall be equipped with Text Messaging facility. The digital telephones shall have keys along with LCD display with associated icons / LEDs.

5.1.10.5 Attendant Console (Operator)

The operator console shall have the following features:

A) General

The attendant shall provide call presentation, chaining process, call-back shall be entirely managed by the PBX. However, it shall be possible to put certain calls on individual hold on keys that have been reserved to that effect. The capacity of the various queues shall have to be unlimited. The information displayed on the terminal shall have to be explicit enough to facilitate unambiguous call handling and

shall give maximum details about the communication (normal call, urgent call, queue status, name of the internal called-party, status of the telephone set etc.).

B) Supervision of the Installation's Stations

An add on unit with attendant console shall be provided to enable single touch dialing and to supervise the status of certain extensions and trunks. A minimum of 48 terminals shall be supervised.

C) Manual or Automatic Answer

The operator shall be able to modify the call answer mode from his/her attendant console. In "automatic answer", calls must be presented and connected without any intervention from the operator.

D) Calling Internal or External Correspondents by Name

To facilitate the operation of attendant consoles, operators shall be able, whatever their communication position (direct call, transfer), to call internal and external circuits according to surname, first name or initials. To assist searches, the system shall be equipped with a spelling and phonetic approximation utility program. User-friendliness being a requirement, the user shall access the service via an alphanumeric keyboard, either integrated or external to the attendant console. The Contractor shall describe in detail the access modes and the number of subscribers serviced.

E) Text Messaging

The system's telephone application shall enable the operator on transfer call status to send a text message to a selected internal subscriber. The operator shall have the choice between sending the message immediately onto the display panel of the subscriber if his/her line is engaged, or sending it to a text mailbox linked to the terminal, whether the latter is free or busy.

This service shall only be provided if the internal subscriber's terminal is compatible with the service (digital terminals with text messaging feature). To facilitate the operation of this service, the operator shall have the choice between several types of messages:

- Pre-programmed messages to answer most common cases (example call back the switchboard, a visitor is waiting for you in reception etc.),
- Pre-programmed messages to be completed (example: call back number XYZ),
- Free messages to be composed entirely by the operator.

The Contractor shall describe clearly all the characteristics of the service and the size of messages, which can be sent in the various communication positions.

F) Hands-free and Amplifier

The operator can freely modify the operating mode of the attendant console and answer calls either in hands-free with the amplifier or with the telephone handset or headphones. When using the latter, the user can operate the amplifier with volume adjust.

G) Ringing levels

The operator shall be able to modify the melody and the ringing volume of the attendant console.

H) DTMF Frequency Transmission

The operator shall have the possibility to use servers controlled by Q23 coded frequencies.

I) Withdrawal of an Attendant Console

There must be a simple procedure to withdraw an attendant console from the group and switch it into a "night service" position. The status of his/her terminal should be clearly indicated to the operator. Calls shall be forwarded to a particular station or a group distributed within the premises.

J) Automatic Transfer of Calls to Attendant Consoles

Then the attendant consoles that are present do not answer calls, the system should, after a time delay, automatically switch to "night service" mode. Calls must be routed towards dedicated stations, the status of the installation shall be clearly indicated to the operators and a simple procedure should enable return to normal situation.

K) Routing Calls to Individual Operator

Incoming calls on Specific trunks shall be possible to route to a particular operator or extension.

L) Additional Services

Attendant consoles enable the user to manage some operation parameters of the system, in particular the following points:

- Create, change or delete a subscriber's attributes,
- Manage service classes (automatic dialing and call transfer etc.)
- Manage the external abbreviated dialing.

All of these operations shall have to be protected by a password programmable by the head administrator.

5.1.10.6 Telephone Features

A) General

Following features shall be available without restriction to all the subscribers or freely programmable:

- Routing of an external bundle on a group or individual user
- Calling an attendant console
- External call barring
- Local calls
- Simultaneous 6 party Conference
- Consult a pending call
- Broker's call
- Recording and transmission of external numbers
- Transit function
- Bundles of external lines
- Call pick-up
- Call pick-up: group

- Put on hold
- Abbreviated external numbers - Minimum 200 numbers
- Directory database in the system - minimum 1000 numbers
- Call parking
- Direct Outgoing Dialing (DOD)
- Direct Outgoing Dialing per cost center
- Direct seizure of external line,
- Dedicated incoming station,
- Dedicated outgoing station,
- Station with direct routing to another station, to an abbreviated number, to an attendant console,
- Station with delayed routing,
- Protection against intrusion,
- Automatic call-back to a busy or free station
- Appointment call-back,
- Storing last dialed number,
- Last number redial,
- Call forwarding - no answer, busy, no answer/busy, fixed
- External call forwarding
- Remote call forwarding
- Night answering service,
- Call diversion on ringing,
- Moving service - without any intervention by the maintenance people, subscriber must be able to move to a new location and by dialing codes at the new locations, he should retain his existing number.
- Padlock with password protection
- Substitution -to temporarily avail all the features of the subscriber extensions at another extension.
- PIN dialing - Each extension should have a PIN dialing, through which one could make calls from a different extension and the metering must be made to the subscriber's extension.
- Call ID on Analogue Extension

B) Push Button Telephones

Features

- Feather touch push buttons for quick and sure dialing.
- Memory storage, upto 22 digits for purposes of redialing.
- Facility for redialing the last number called by pressing the repeat
- Push button just once.
- Ringing facility with adjustable volume.
- Digital pulses during dialing to be muted to eliminate harsh sounds.
- Compatible with P&T network.
- Built in automatic gain control.

C) Specifications

1. System voltage : 48V DC + 10 %

2. Pulse Rate : 10PPS

3. Break make rates : 66:33/60:40

4. Inter-digit pause : 800m secs. (minimum)

5.Loop resistance from the exchange: 1 K ohms (maximum)

The push button telephones must confirm to CCITT standards.

The telephone offered shall be approved by the TRO for interface with P&T network. A copy of the certificate shall be enclosed.

D) Following Additional Features shall be built-in the System :

Multi Line Digital Stations

This function shall enable a user to simultaneously establish, from a station answering only one number, several outgoing or incoming communications. Only one communication is active at a given time, the other engaged communications being on hold; the user shall be clearly informed of the status of the pending communications.

Each key on the station can be allocated to a different call number, hence allowing differentiation of the calls. Contractor to mention how many multiline numbers can be programmed on one digital set.

Multiple Keys and Number Stations

Combining the two previous functions, each directory number can have several keys. The Contractor shall specify the number of manageable keys per station, a minimum of 6 keys which can be allocated to the multiple key / multiple number function would be desirable.

Executive/Secretary sets

- Call Filtering - Certain calls on the Executive set should be programmed to reach directly, whereas all other calls shall be routed to the secretary
- Real time diversion without picking-up the call

Work Groups

Status to be supervised (Visual and audible) on a digital set by associating a key to an extension and monitor for the following status:

- Free station
- Busy station
- Station receiving a call (ringing)
- Hunt Groups of stations - sequential / cyclical / parallel
- Utilization of ISDN Additional Services

The Contractor shall submit the list of ISDN additional services to be used on proprietary stations. The main requirements are as follows:

- Identification of an ISDN Caller

Some external subscribers must be identifiable by their name or the name of their company upon display of the calls on the attendant console or **on** proprietary

stations. The caller's name shall be maintained after pick-up and shall reappear during all communication modes (back-and-forth, conference, and transfer).

- List of unanswered calls upto 8 calls

Automatic forwarding to Night-mode

Night-mode shall be automatically activated by the clock system and it is required to have night service based on the time of the day.

Additional Features

Following features shall be available with the EPABX system in addition to the above.

- Music-on-hold

The system shall be equipped with in-built music-on-hold device that shall have a capacity of 10-15 seconds and shall have good acoustic quality.

- Automatic Attendant

The proposed telecommunications system shall be equipped with 4 port P.C. "automatic attendant" feature allowing, the reception of external calls and offering to direct them interactively to a pre-defined service or subscriber. The interactive dialogue shall be based on DTMF. Errors (incorrect codes) shall be handled by an information message and return to the current message. If no Q23 code is received, the call shall automatically flow over to **a** dedicated number, after a pre-set delay.

- Computer Telephone Integration

CT1 shall support for following computer environment- Digital, IBM, Microsoft, etc.

The physical interfaces supported shall be on V.24, RS232, SO, TCP/IP. Both first party and third party CTI solutions shall be supported.

- IP Components

The EPABX shall have in-built interface for IP functionalities. The Contractor shall enclose the detailed implementation schematic for VoIP and shall quote price for 10 VoIP users. It shall support the following:

- Connection of a server via LAN-LAN router and LAN-WAN (ISDN)
- Voice over IP and Frame Relay.

5.1.10.7 System Administration - Management terminal

The proposed system should

- Offer GUI based windows software with user-friendly access to the various proposed services
- Be protected by an overall access code and offer several secondary access levels
- Enable overall management of the system
- Provide menus in English, without obligation to answer questions with hexadecimal characters or mnemonics. A Windows-compatible application would be desirable

5.1.10.8 Main distribution frame

The main distribution frame for Field side and Exchange side shall be housed in a metal cabinet and shall be equipped with Krone modules for 200 Pair terminations. An Intermediate Distribution Frame shall also be provided for 200 Pairs with Over-voltage and

over-current protection for all the Trunk lines. The interconnection between MDF and IDF shall be done using Jumper Wire. The Contractor shall do all termination of cables and jumpering at the MDF.

5.1.10.9 Power Supply

A) FCBC

The Float cum Boost Charger shall be sized to supply power to the PBX for the required capacity and it shall simultaneously allow re-loading of the battery within 10 hours maximum. FCBC shall also be provided for the Remote units also.

B) Battery

Sealed Maintenance Free Lead Acid battery shall ensure automatic standby for the PBX in case of failure of the electric power supply or the rectifier. A minimum back-up of 6 hours is required.

5.1.11 List of Approved Makes

S. No.	Equipment / Component	Preferred Makes
1	HT Switchgear	Adlec (Schneider) / SPC Electrotech (L&T) / RISHA (L&T) / NITYA (Siemens)
2	LT Switchgear	Adlec (Schneider) / RISHA (L&T, ABB) / SPC Electrotech (L&T) / Vidhyut Control (L&T) / NITYA (Siemens)
3	Distribution Boards	SPC Electrotech (L&T) / NITYA (Siemens) / RISHA (L&T, ABB) / Adlec (Schneider)
4	Distribution Transformer	Areva / Emco / Crompton / BHEL / Voltamp / Bharat Bijlee / PETE Hammond
5	HT cables	Havells / Ravin / Gemscab / Gloster / Paramount
6	LT Power cables	Havells /Ravin / Gemscab / Gloster / Grandlay / Paramount
7	Control Cables, Wires & Flexible cables	Havells / Gemscab / Ravin / Gloster / Grandlay / Paramount
8	Copper Wires PVC FRLS	Skytone / Echo Cables / National / Finolex / Polycab
9	Cable Glands/Lugs	Jainsons / Dowells / Gripwell / SMF
10	Cable Trays (FRP)	Ercon / Indiana / Sumip Composites / Sintex
11	Capacitor Panel with Banks and other related accessories	L&T / Epcos / Schneider / ABB / Asian / Madhav / Havells
12	Battery	Exide / Amco / Amara Raja / Chloride / HBL
13	Battery Charger with DCDB	Chhabi Electricals / Caldyne / Mastek / DB Electronics / HBL
14	Diesel Generator Set	Powerica / Jakson / Sudhir/ Greaves
15	Alternator	Crompton Greaves / Kirloskar / Stanford
16	Lighting fixture with street light poles	Bajaj / Philips / GE Lighting / Havells / Pharox / Surya
17	High Mast	Bajaj / CGL / Philips / Surya

S. No.	Equipment / Component	Preferred Makes
18	Plate-Switches & Sockets, Boxes	MK / Crabtree (Havells) / Anchor
19	GI Conduit with accessories	BEC / AKG / SENCO / Jindal
20	VCB	Siemens / L&T / ABB / Schneider
21	ACB	Siemens / L&T / ABB / Schneider
22	MCCB	Siemens / L&T / ABB / Schneider
23	MCB / ELCB / RCB / MPCB	Siemens / L & T / MDS / Schneider / Havells
24	Fuse/Link	Siemens / L&T / Alstom / Schneider / C&S / Areva
25	Switch Fuse Units	Siemens / L&T
26	Contactors	Siemens / L&T / ABB / Schneider
27	Indicating Lamps / Push buttons	Siemens / Schneider / Teknic / Kaycee / L&T / Essen / Vaishnav / BCH / C&S
28	Push button stations	Siemens / Schneider / Teknic / Rishabh / L&T / BCH / Control Group
29	Meters (digital) MFM	Schneider (Conzerv) / L&T / Secure
30	Voltmeter / Ammeter / PF Meter / Frequency Meter/ KWH Meter	AEI / IMP / MECO / INDCOIL / Enercon / L&T / Rishab / Siemens / Industrial Meters
31	Selector Switch	L&T / Siemens / Schneider / Kaycee / Salzer / C&S / Vaishnav
32	Auxiliary Contactors/ Relays	L&T / Siemens / BCH
33	Overload Relays (Hand Reset Type)	L&T / Siemens / BCH / Telemachanique
34	Protective / Auxiliary Relays	Areva / Schneider / Siemens / EasunReyroll / ABB / Telemechanique / L&T
35	Time Delay Relays	BCH / Siemens / L&T / English Electric
36	Power Contactor with 2NO+2NC	L&T / Siemens / Telemechanique
37	Timer	Siemens / L&T / BCH / Schneider
38	Terminal Blocks	Elmex / Connect Well
39	Current Transformer/ Potential Transformer	AE / Kappa / L&T / Siemens / Pragati
40	Plugs & Sockets	Havells / Legrand / Hensel
41	Welding Sockets	B&C / BCH
42	PVC Conduit and accessories	BEC / Polypack / Precision /AKG
43	Cable Termination Kits & Straight Through Joints	Raychem / M-Seal (3M)
44	Motors	BHEL / Kirloskar / Crompton / Siemens / Havells
45	Chemical Earthing	Ampere Protection / JK Earthing / JMV/OBO
46	Exhaust Fan	Bajaj/Orpat/Havells
47	Axial Flow / Exhaust Fans	Almonard / Dynamic Engineerings
48	Air Conditioners	O'General / Samsung / Blue Star / LG / Hitachi
49	EPABX	Panasonic / Coral

5.1.12 CCTV Surveillance System

5.1.12.1 General

Surveillance CCTV system is required to ensure surveillance of required locations as well as create secured record for post event analysis. The system shall provide an online display of video images on LED monitors located on each Slat System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components.

The communication between the cameras and the Camera Control Room shall take place to ensure the maximum availability, Real time Delivery of the Datagrams and further maximize determinism. In addition to the Wireless, Backbone of the network an additional fiber optic as optional backbone has to be built in order to ensure the failsafe working of the CCTV surveillance in the event of unexpected failure of the system components such as wireless routers etc.

System shall have expansion possibility with the available hardware (system shall have the facility of additional camera installations beyond the originally planned capacity). It shall be an open standard based integrated system with IP network aimed at providing high-speed automatic operation for best performance. It shall use video signals from various types of indoor/outdoor cameras installed at different locations. Joystick and mouse-keyboard controller shall be used for Pan, Tilt, Zoom, and other functions. System shall have a combination of Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards.

Camera server shall be NVR server based with appropriate Audio and Video Management System backup system and software. Each camera server shall handle 60 or more cameras. CCTV system shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a sufficient period. The recording resolution and frame rate for each camera shall be user programmable.

5.1.12.2 Equipment Specifications for CCTV Surveillance System

A. Nvr Server

The NVR shall have enterprise class reliability with a RAID 6 hard drive configuration and the option for redundant power supplies. In addition, both the hard drives and the power supplies shall be hot-swappable for online repairs. The NVR shall have upto 10 TB effective recording capacity that is expandable using a storage expansion unit. Quality Video Resolution: 640 x 480, 320 x 240 (default), 192 x 144. The Image Quality shall be of JPEG (favour clarity, standard, and favour motion) and MPEG4. It shall support a Frame Rate of 30 frames/sec (640 x 480, 320 x 240 or 192 x 144).

It shall support IPv4/v6 Dual Stack Supported Network Protocols. It shall support Simultaneous Viewing with simultaneous accesses with Image Transfer via E-Mail (SMTP) or FTP, SMTP, FTP, and HTTP etc. It shall be complete with standard keyboard, 21 inch XVGA LED colour monitor, mouse controller, CD/DVD drives, network cards.

B. Workstations

Data terminal computers shall have high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21 inch XVGA LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Processor	Intel i5 processor,
Clock Speed	3.6 GHz
Random Access Memory	4GB- DDR2-ECC-SDRAM Clock Frequency = 1667MHz
Hard Drive 1 Optical Drive	320 GB SATA CD/DVD read write
Communication Ports	Parallel Port-1,Serial Ports (Universal)-3, USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit/10/100 MBPS Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient temperature	$50^{O}C$
Operating System	Windows 7/ 8/ 10
Power Source	240 V Ac,50/60 Hz
Display Type	Compensated TN ,Full colour TFT LED Luminance :1150cd/m2
Resolution	At least 1280*1024 (NI)
Size	21 inch Diagonal
Operating Condition	Temperature : 0ºC-40ºC Humidity : 20% -80%
Contrast Ratio	30000:1
Viewing Angle	140ºH, 140ºV
Safety Standards	UL6500/C-UL

C. Optical Fibre Cables

Multimode/Single mode (depend upon the distances), armoured optic cable standard cable shall be used. It shall have rugged design for industrial applications indoors and outdoors. It shall have high immunity to noise and electro-magnetic fields and shall be Tap-proof and radiation shall be limited to applicable standards. It shall also be silicon free and free from varnish-moistening substances.

F. Ethernet Cable (Cat 5e)

Category-5e cables shall be built tough enough to withstand the harsh environmental conditions and mechanical stresses. The cable shall also provide more stable electrical performance with less attenuation and greater resistance to EMI/RFI.

G. Cameras

All the cameras shall be IP based. They shall have an enclosure of minimum of IP-67 while outdoor cameras to be of IP-67. They shall also be outdoor ready with day/night functionality

36x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability with advanced digital Signal Processing Capability, High Horizontal Resolution, Day and night Type, 360 degree continuous Pan Rotation with complete power supply and accessories.

Image Device	Better format CCD sensor
Optical Zoom	36 X or better
Number of pixels	1280X960 or above
Scanning system	PAL
Pan Travel	360º continuous
Tilt travel	0 - 90º continuous
Iris Control	Auto
Focus	Auto
White Balance	Auto
Electronic shutter	Auto
S/N ratio	>= 40 dB
Frame Rate	PAL – up to 30 frames per second in all resolution
Operating Temperature	- 10 º to 60 º C.
Operating Range	Up to 190 meters
Mounting Frame	Aluminum (or any which suits whether conditions)

I. Mounts

All the cameras shall have appropriate mounts based on the camera design and the functional requirement of the same.

J. Enclosures

All the cameras shall have IP-67 appropriate dust tight enclosures ready for use in small Particle and dusty environments it shall also include Heater, Blower, Air Funnel Kit, Sun Shield and Sun Visor depending on the mounting location and requirement.

K. Video Management Software

Processor	Intel Xeon i5 processor
Clock Speed	3.86 GHz
Cache Memory Size	12 MB Cache L3 1333 MHz front side bus
Random Access Memory	8 GB DDR4

	Clock Frequency: 1333 MHz
Hard Drive 1	10 TB (7,200rpm) SAS
Hard Drive 2	6 TB GB SOS
Communication Ports	Parallel Port-1, Serial Ports (Universal)-3. USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient Temperature	$50^{O}C$
Operating System	Windows

The software shall be IP-Surveillance software that works with the network cameras to provide video monitoring, recording and event management functions. It shall enable recording of video continuously, on schedule, on alarm and/or on motion detection. The software shall have multiple search functions for recorded events. Remote viewing and playback shall also be possible with the use of the client software.

5.1.13 Recommended Equipment/Component Vendor List

Make of the equipment under supply items shall be selected as per the following list. Employer, however, reserves, the right to select the particular make during detailed engineering for uniform design and inventory. Approval of makes for items not mentioned in this list shall be obtained from Employer/Employer's Representative Engineer before initiating procurement action.

ITEM	**RECOMMENDED VENDORS**
Servers	Hewlett Packard / IBM / Dell
LED (65")	Samsung / Sharp / Panasonic / LG / Sony
Workstation Terminals	Hewlett Packard / Dell / IBM
LED Monitors (21")	Sony/Samsung / LG / AOC/ Hewlett Packard
Network Printers	Hewlett Packard / Canon / Epson / Samsung / Lexmark
UPS	APC / Eaton /Toshiba/Best Power /Emerson Hi-Rel
PLC	Siemens / Allen Bradley /ABB /Schneider/ Honeywell / Yokogawa / GE
CCTV	Honeywell/ Bosch
Network Components And Accessories	
Jack Panel	Molex / Signamax /Brand-Rex
Cat5e Cable (UTP)	Amp / D-Link / ADC
Cat6 Cable (UTP)	Amp / D-Link / ADC

ITEM	RECOMMENDED VENDORS
UTP To OFC Converter	Moxa / D-Link
LIU (Light Guide Interconnect Unit)	D-Link / Moxa
Ethernet Switches	D-Link / Cisco / Moxa / Siemens / Nortel
UTP Patch Cords	AMP / ADC / D-Link
UTP Information Outlet	D-Link / Molex / ADC
Instrument Cable	Cords Cables / KEI / Associated Cables / Universal Cables
Panel/Cabinets	Rittal / ICA / Pyrotech
JB/Cable Gland/Plugs	Hensel / Rittal / Emiter
OFC Cable	Molex / D-Link / Finolex / RPG Cables Ltd. / Sterlite Industries
Other Equipments	
3d Level Scanners	EIP Technologies Pvt. Ltd. / Equivalent
RTD	Pyroelectric Equipments/General Instruments / A.N. Instruments
Relays	Omron / OEN / Jyoti

NOTE: - Makes like 'or equivalent' are not acceptable. Other makes proposed shall be submitted to the Employer with back-up documents and PTR (Proven Track Record) for prior approval.

6 SPECIFICATIONS – MATERIAL HANDLING SYSTEM/ EQUIPMENTS

6.1 GENERAL

The Proposed Inter modal IWT terminal at Kalughat shall cater containers only.

The container shall be handled using mobile harbor crane with spreader at berth, Reach stackers at yard and flatbed trailer trucks for internal transfers.

The terminal parameters shall be adhered to in the bid. Berth layout, crane's and reach stacker's general requirements, scope of work and specifications, barge sizes and dimensions, clearances, water level details, etc., are given in this document against respective sections. Those required but not given here shall be bidder responsibility to collect and implement for guaranteed performance.

6.2 MECHANICAL EQUIPMENT

6.2.1 General

Following are the specifications for Mobile Harbour Crane, Spreader, Reach stacker and Flatbed truck which are to be followed for design and construction of jetty, stockyard, internal roads and parking area etc. **However, all these mechanical equipment are not in Bidder's scope of work.**

6.2.2 MOBILE HARBOUR CRANE (MHC)

Mobile Harbour Crane shall be of rubber-tyre, self-contained construction and shall be equipped with a diesel engine as a prime mover for crane operation and travelling. The crane shall be of four-rope construction and shall be designed and equipped for handling containers with automatic Spreader. Crane will cater to barge up to 3,000 DWT size with the dimension of 95 m x 15 m x 2.5 m.

Being a new terminal and to have edge in the industry market, equipment should have maximum efficiency to perform highest in its class.

6.2.2.1 Main Technical Requirements

The following minimum operating characteristics are required:

6.2.2.2 Load Capacities

The crane shall have a lifting capacity of 45 T at 26 m maximum reach with under spreader capacity 30.5T minimum from crane centerline. Spreader weight considered as 9 t. Total weight of the loaded container is considered as 30.5T.

6.2.2.3 Classification of Crane and Machinery

The crane and its machinery shall be classified according to the FEM 1.001 (Rules for the Design of Hoisting Appliances) and shall have the A6 classification.

6.2.2.4 Operating Speeds

The following speeds shall be provided as a minimum:
Hoisting/ Lowering: 0 - 90 m/min
Slewing: 0 - 1.6 rpm
Luffing: 0 - 75 m/min
Travelling: 0 - 90 m/min

6.2.2.5 Main Dimensions

Main dimensions shall be suitable to handle 40ft Container having 30.5T weight at 26m radius or outer reach of barge outer edge.
Minimum outreach of the boom from crane centerline: 10 m
Maximum outreach of the boom from crane centerline: Not less than 26 m
Height of boom pivot point above ground: Minimum 12.5 m
Height of eye level in tower cab: Minimum 17.5 m
Maximum hoisting height on hook above ground: Maximum 33.5 m
Minimum hoisting height on hook below ground: 14 m

6.2.2.6 Quay Load Arrangements

Uniformly distributed load : 1.5 T/m^2
Max. Load per tyre : 5.02 T

6.2.2.7 Environmental Conditions

The crane shall be designed to work safely and reliably under the following environmental conditions:

I. Daily temperature range variation : ± 15^0 C
II. Maximum operating wind speed : 24 m/s
III. Maximum wind speed for travelling : 24 m/s
IV. Maximum wind speed out of operation with boom in steepest position : 46 m/s
V. Maximum gradient for travelling
    a. In direction of travel : 6 %
    b. Perpendicular to direction of travel : 2.5 %

6.2.2.8 Safety Devices

The crane shall provide the following safety equipment as a minimum:

I. Safe load indicator
II. Mechanical interlock of chassis and superstructure during travelling
III. Stabilizer monitoring
IV. State-of-the-art electronic limit switching system
V. Safety valves at hydraulic cylinders

VI. Anemometer
VII. Emergency stop buttons at various locations of the crane
VIII. Video camera at the boom tip
IX. Appropriate lighting system for night-time operation
X. Crane management system (optional)

6.2.3 SPREADER

Electro-Hydraulic Telescopic fully automatic Spreader with 35t SWL shall be required to handle 20ft & 40ft containers. Each spreader shall be fitted with hydraulically retractable twist lock housings mounted on the main center section. It shall also have Telescopic design, CG adjustment, flipper guides and twist lock including all supporting accessories.

6.2.4 REACH STACKERS

Reach stackers shall be required to handle and stack containers in the yard to support import and export cargo movement with flexibility. It shall be used to load and unload 20ft and 40ft containers from flatbed trailers.

Table shows the basic requirement of reach stacker specification.

SL. No.	Description	Data
1	Lifting Capacity at load center at 1.965m	40000 Kg
2	Lifting Capacity at load center at 3.815m	25000 Kg
3	Lifting Speed, unloaded – at 70% of rated load	0.42 - 0.25 m/s
4	Lowering Speed, unloaded – at rated load	0.36 m/s
5	Traveling Speed Forward, unloaded - at rated load	21 - 25 Kmph
6	Traveling Speed Backward, unloaded - at rated load	16 - 18 Kmph
7	Engine	Diesel
8	Transmission	Gearbox & clutch
9	Wheels	Pneumatic

6.2.5 FLATBED TRAILOR TRUCKS

40 ft., 40 tonner flatbed trailer trucks are to be used to transfer the containers from jetty to yard and from yard to jetty. It shall be used for interplant transfer of empty and loaded containers.

7 ROAD WEIGH BRIDGE

2 no. of road weigh bridges shall be supplied. The weigh bridge structure shall be robust in construction with ample safety margin above the rated capacity. The lower structure of the platform shall comprise of wide flanged steel beams and high grade tested steel. The structure shall be sand blasted to SA 2½ grade and suitably painted with special anti-corrosion epoxy based paint. The assembly shall be designed to compensate for expansion and contraction between the Weigh Bridge and foundation, caused by temperature variation.

The load cells shall be sealed and compression type suitable for pit less weigh bridge installation. The load cells shall be of rated capacity 23T (approx.) each having safe overload limit of 150% and breaking load of 300% of rated capacity. Each load cell shall have safe temperature range 0-65 degree Celsius and shall be weather proof IP-68 protection.

Weigh bridge electronics shall be micro controller based with standard software capable of providing various kind of information on selectable basis. The system shall be provided with communication facility with the main PIC in the control room and a real time clock to print date and time on the printouts. The system shall be provided with suitable PC with software and dot matrix printer of latest technology is given below:

7.1 Specification Data Sheet - Road Weigh Bridge

S. No.	Description	Data
1.	Type	Pit less, Static
2.	Capacity	100T
3.	Accuracy	± 0.05% of Full scale
4.	Platform size	15 m x 3 m
5.	Trucks to be weighed	Heavy duty Trucks / dumpers
6.	Operator interface	Menu driven
7.	PC & Printer	Required
8.	Auto zero & Auto Calibration	Required
9.	Anti-skid to plate	Required
10.	Stamping by W&M Inspector	Required

8 SPECIFICATIONS - FIRE FIGHTING SYSTEM

The equipment and materials covered by this specification are subject to the referenced attachments. The Contractor shall be responsible for and governed by all the requirements of this Specification and Standard Conditions of the Contract.

8.1 Scope of Work

The Scope of Work is for the installation of Fire Fighting Systems in Container yard and Jetty area in the Kalughat terminal complex. The firefighting system shall consist of hydrant systems using raw water in Container yard and Jetty area.

The specification outlines the conditions and functional requirements for the design, manufacture/ fabrication, delivery at Site, erection, testing, commissioning and handing over of the facility covering mechanical, associated civil, structural and electrical works including furnishing of all labour, material and services required for the "**Fire Fighting System" (FFS)**.

The specifications and attached drawings outline the functions and the operating characteristics, which the systems must fulfil. Alternative features other than specified may be acceptable subject to the approval of the Employer / Engineer.

All approvals and licenses required by all authorities having regulatory powers to control the fabrication, erection and operation of the FFS within the State of Bihar / concerned statutory Government Authorities. Management, coordination, planning of the work at all location of the works at site including occupational health and safety, quality control, design, manufacturer, delivery, inspection, erection, testing, commissioning & training.

The scope of work shall also include, but not limited to, supply and installation of all supports, platforms required if any, foundations for pumping units, diesel engines, piping, pipe fittings, valves, accessories, instrumentation to provide water to respective hydrants at the required flow and pressure. Digging of trenches wherever required and filling it as back as per specification, chipping paved area, cutting of roads/and or culverts repaving and repairing the cut roads and associated civil, electrical and structural works required , if any.

All consumable materials for welding, erection, fuel for construction facilities / equipment of the tenderer, consumables for temporary power and up to the handing over. Clean-up site of all debris and temporary structures on a daily basis and final clean up and handing over.

All electrical safety requirements during site fabrication, erection, testing and commissioning, including adequate earthing of erection/ fabrication equipment and machines. Proper safe storage of all equipment and materials delivered at site in areas designated by the Engineer / Employer in line with the Customs Employer Regulations, if applicable.

The detail scope is mention as below.

Sr. No.	System	Area	Broad Scope
1.	Yard Hydrants	Periphery of Container yard & Jetty Area	1) Underground and above ground piping with fittings of hydrant network at periphery of Container yard. 2) M.S ERW pipe with fittings for hydrant posts, water monitor stand post (wherever applicable), fire escape risers etc. 3) Fire hydrants in Under/Above ground. 4) Cast steel wafer type butterfly valves in underground valve chamber and above ground for riser. 5) Fire hose pipe, branch pipe and nozzles, hose reel, hose box. 6) Painting for above ground M.S piping 7) Wrapping & coating for underground M.S piping. 8) Structural support with painting for pipe supports. 9) Any other work not mentioned but deemed necessary for completion of system.
2.	Fire Extinguishers	All operational multi-storeyed buildings, parking area, jetty area. etc	1) 4.5Kg CO_2 extinguishers 2) 10Kg ABC type extinguishers 3) Foam type extinguishers 4) Sand bucket

8.2 Main Technical Requirements

8.2.1 General

This section of specification covers specifications and broad design basis for various equipment and services of fire protection system.

8.2.2 Design Creteria

The main fire protection system shall consist of a fire water hydrant system serving the whole terminal including Employer's plant/ facilities/ buildings. The complete fire protection systems shall be as per the guidelines/codes/standards/rules of the TAC/NFPA/IS: 3034/OISD etc.

8.2.3 Fire Water Tank and Pump House

8.2.3.1 Water Tank

Fire water tank shall be compartmentalized i.e. (2Nos. compartments for FFS) shall be provided for storage of service water at proposed location, each having capacity of 155 m^3.

Water for firefighting system shall be drawn from fire water tank. The water for utility requirement shall be stored in one of the any compartment of fire water tank. The suction level of utility shall be above the fire water storage requirement.

The water intake line including piping, valve, fittings, instruments etc. from battery limit is to be considered by bidder as a part of contract.

8.2.3.2 Pump Room

Firefighting pumps shall be installed in firefighting house adjacent to fire water tank at proposed location.
The tentative list of equipment shall be part of pumping system as given below. However it is bidder's responsibility to ensure that the capacity, head, and size of equipment given below is sufficient to meet the requirement of system.

- 1No. electric motor driven Horizontal Split casing Pump (main pump) of capacity 137cu.m/hr., 88MWC.
- 1 No. diesel engine driven horizontal Split casing type (stand-by pump) of capacity 137cu.m/hr., 88MWC.
- 1 Nos. electric motor driven horizontal Split casing type Jockey pump of capacity 10.8cu.m/hr., 88MWC.
- Diesel engine control panel with 2x100% battery and battery chargers.
- MS Piping and fittings.
- Valve, instruments and other accessories.
- Diesel tank for Diesel engine.
- MCC cum annunciation panel for proposed firefighting pumps.
- Cabling, earthling up to earthing pit and cable trays.
- Structural support for piping and cable trays.
- Sump pump with associated piping and hardware.

8.2.4 Hydrant System

Fire Fighting System shall be designed to provide adequate fire protection for the facility as per the guide lines of the Tariff Advisory Committee's Fire Protection Manual.

The Fire Hydrant System shall be installed at periphery of Container Storage yard & jetty area.

Wet riser shall be provided for all buildings with landing valve, hose pipe and branch pipe with nozzles.

Hydrant mains shall be laid both above ground and underground to suite the master planning requirements. Crown of the pipe in underground installations shall be laid at a minimum depth of

1.0 meter below ground level. As an additional safety, RCC encasing pipes shall be provided to protect pipe in the road crossing area.

- The proposed hazard shall be considered as “Ordinary hazard “occupancy in line with 'TAC MANUAL- General Design of hydrant system'.
- Spacing of hydrants (outdoor) shall be 45 m (max.)
- Total number of outdoor and Fire escape hydrants shall be determined as per guide lines of TAC regulations. Similarly number of branch pipes with nozzles and hoses shall be determined based on total number of outdoor/ internal hydrants.
- Each of the external hydrant valves shall be provided with a hose box. Each hose box shall contain two (2) numbers of 15 m long hoses & coupling, branch pipes and nozzles, spanners, etc.
- For landing valves of various off-site buildings, the hose box shall have two (2) numbers 7.5 m long hoses, branch pipes, couplings, nozzles, spanners, etc. as per TAC guidelines.
- Butterfly valve shall be provided in each ring main / sub loops to unable to take up part of any of the ring main for maintenance without any loss of the system in balance part.
- System shall be designed to cater minimum 3.5 kg/cm2 pressure for hydrant. The yard pipe lines are designed to limit the velocity in pipe 5m/s (Max.)
- The Piping Network for fire escape and yard Hydrant System shall consist of underground or above ground piping with yard Hydrants at proposed Container Storage yard, jetty area and fire escape hydrants with wet riser at off-site buildings shall be provided.
- Each Riser for Fire Escape Hydrant shall be provided with Isolation valve and Air release valve at top.
- Proposed Hydrant ring main is of M.S ERW Heavy grade pipe as per IS: 1239 Part-I up to 150NB and IS: 3589 Gr.410 for pipe 200NB and above with minimum thickness of 6.35mm.
- Corrosion protection measures - Internal Rubber lining and external and external painting (for above ground) and wrapping coating (for underground) pipes Hydrant valve, hose pipe, branch pipe and all other equipment

Hydrant System Operation Philosophy

The complete piping network of hydrant system shall be kept pressurized, and pressure in the system is maintained by Jockey pumps.

In the event of fire, hydrant around the affected area shall be started, this action will result in pressure drop in the system, once pressure drop is sensed by the system, main fire pumps shall start sequentially to meet desired flow and pressure in the system.

8.2.5 Fire Extinguisher

Fire extinguisher shall be provided as per the TAC guide lines

- Portable Fire Extinguishers are proposed to be placed at strategic positions across the entire facility.
- Fire extinguishers shall be provided in all the Buildings, Pump house etc.
- 6 Kg Dry Chemical Powder and 4.5 Kg Carbon di Oxide extinguisher shall be provided with Sand Buckets as per recommendation in TAC.

8.2.6 Selection of Pump capacity

Pump capacity shall be selected in accordance to TAC Fire protection manual, clause 7.4.1.4.1 Table-2, for ordinary hazard Abstract of the guide line is reproduced below:

S. No	No of Equivalent Hydrants	Pump Capacity
1	Not exceeding 20 hydrants	137 m³/hr.
2	Exceeding 20 but not exceeding 55 hydrants	171 m³/hr.
3	Exceeding 55 but not exceeding 100 hydrants	273 m³/hr.
4	Exceeding 100 plus 273 m³/hr. for every additional 125 hydrants or part thereof	

8.2.7 Selection of Pump Head

- Pump head shall be selected in such way that minimum 3.5 Kg/cm2 pressure shall be available for hydrant located in most remote area of the plant from pump house.
- To ensure the pressure availability in most remotest area of the plant, Pressure drop calculation shall be done as per "**Hazen Williams** **"** formula considering half of the flow shall be discharged at remotest area and half of the flow shall be discharged in balance part of the plant.

8.3 FIRE DETECTION AND ALARM SYSTEM

8.3.1 Scope of work

The Scope of Work is for the installation of Fire Detection & Alarm system in all buildings in the Kalughat terminal complex.
The specification covers the design, manufacture, testing, packing and supply of Fire Alarm & Smoke Detection System incorporating manual break glass boxes and central annunciation panel employing relays/static components.

8.3.2 Applicable Codes and Standards

CODE	DESCRIPTION	Reaffirm
IS 2189 (2008)	Code of practice for installation of automatic fire alarm system using heat sensitive type fire detectors (applicable clauses only)	
IS60947 (2007)	Low voltage switchgear and control gear Part 1 general rule	April 2012
IS 3826 Part – 1 (1970)	Connectors for frequencies below 3 MHz General requirements and tests	June 2013
IS 3700 (Applicable parts) (1970)	Essential ratings and characteristics of semi conducting devices	March 2012

IS60079(2006)	Explosive atmospheres: Part 11 Equipment protection by Intrinsically safety	Sept. 2013
IS 5469 Part 1 (1969) Part 3 (1973)	Code of practice for the use of semi- conductor junction devices Applicable to All devices Diode Thyristors	Sept. 2011 March 2012
BS 5839-1 (2013)	Code of practice for installation of fire alarm system.	
NFPA 72 (2013)	Code of practice for automatic fire alarm system.	

8.3.3 Fire Alarm Panel

Fire sensed by the field equipment's like detector , Manual call point shall be monitored by fire alarm panels. Fire alarm panels shall be analogue addressable microprocessor based type. Fire alarm panel shall be Gas release type. Fire alarm panel shall be provided with Ethernet communication port.

8.3.4 Analogue Addressable Fire Alarm System

The microprocessor based analogue addressable fire detection & alarm system shall be computer aided utilizing distributed processing techniques. The system shall be suitable for integration with CCTV, Public Address system, Gas Detection system and HVAC system. The system shall include not less than the following:

Central Fire Alarm panel (CFAP)

a) The CFAP or central processing unit shall be a special purpose microprocessor operating as per software program, which shall provide central control and monitoring function of the entire fire alarm system.

b) CFAP shall communicate with various I/O devices, , repeat alarm panels, I/O multiplexers, mimic panels, PCs, visual display units (VDU), key boards, printers etc. located at central/various locations of the plant.

c) CFAP shall have the facility to scan the data received from the repeat panels, VDUs etc. through bi- directional communication network.

d) CFAP shall be modular in design and shall contain 100% redundant microprocessor based master unit, processing unit, signalling unit & power supply unit. The CFAP shall serve as an interface and controller for connected PCs having graphics/text facility located at central location.

e) CFAP shall be designed specifically for fire alarm and protection system applications and shall provide status, alarm, shutdown signals in pre-defined manner, initiate alarms, synchronise all activities, provide repeat alarms and other signals as specified.

f) CFAP shall provide various event initiated programs (EIP) in a chronological manner. EIP shall be initiated by any of the user defined following parameters: day, time, alarm, return to normal, change of status and hardware failure. CFAP shall have non-volatile memory for reliability. The system shall provide multi levels of command priority to assure that high level commands are not overridden by lower level commands.

g) In case of peer to peer fire alarm network system no "FAP" shall be central one as information exchange is possible between any nodes. Here node means any panel connected to the network.

h) It shall have the facility to display the affected area on the VDU and provide the instructions to suppress the cause. High resolution graphic software shall be provided for display. The graphics shall have many layers of penetration. The VDU shall either be touch screen type or menu driven using mouse/keyboard. However instead of graphic display, VDU with only text display shall be provided, if specified in the data sheet

i) Unless otherwise specified in the data sheet the CFAP shall be designed to provide multicolour display on the VDU

j) Suitable communication interface cards shall be provided in the CFAP to interface with, repeat alarm panel..

k) Monitor screen shall have dedicated areas for the following functions:

- Alarms and returns to normal
- Menus, commands, reports & programming.
- Time, day & date
- Alarm and all other changes of status shall be displayed on the screen area reserved for this information. The following information shall be provided as a minimum.
- Condition of detector (Alarm / trouble)
- Type of detector
- Location of detector and numerical system address
- Emergency instructions

On the receipt of alarm an audible alarm shall sound and the condition and detector type shall flash until acknowledged by the operator. Return to normal shall also be annunciate and shall require operator acknowledgment.

l) The system shall have multiple levels of priority for displaying alarms. Should multiple alarm occur the first received highest priority alarm shall be displayed on the screen until acknowledged by the operator. Then the next highest priority alarm shall be displayed on the screen until acknowledged by the operator. Should a higher priority alarm occur the higher priority alarm shall replace the lower priority alarm on the screen and the lower priority alarm shall be retained in memory and re-displayed after priority alarm is acknowledged

m) The system shall provide sufficient memory so that no alarm shall be lost. A message highlighted in reverse video, shall advise the operator when other unacknowledged alarms are present in the system.

n) The VDU keyboard shall use function keys with English descriptions to initiate all system functions. Typing abbreviations or using unlabelled or numerical function buttons is

unacceptable. When a function key is pressed, the monitor shall lead the operator through the function by asking him to choose one of several clearly defined options (menu penetration). When a specific detector must be addressed, a distinct numerical keypad shall be used to speed up and simplify the operation. On command from the operator, system reports shall be displayed on the VDU screen and / or output on the printer in a chronological manner.

o) Multiple levels of access to the system shall be provided for operators and supervisors via user defined passwords. The following functions shall be provided for each level.

- Operator level access functions:
  - Display system directory, definable by detector type.
  - Displays status of an individual detector.
  - Manual command (alarm with an associated command i.e. secure / accesses alarm shall use the same system address for both functions.
  - Report generation, definable by detector type. Reports shall be output on either the monitor or printer as desired by the operator.
- Supervisor Level Access Functions:
  - Reset time and date
  - Hour day scheduling
  - Enable / disable event initiated programs, printouts, initiators.
  - Enable / disable individual hardware points and system components.

p) Printer used in the system shall provide real time records of the system events and provide system reports on demand. Printer shall be microprocessor controlled high speed read only (RO) type.

q) The system printer (PTR) shall be letter quality dot-matrix printer, 132 characters wide and shall have a 96 character set. The printer shall have a microprocessor controlled bi-directional logic seeking head. The printing speed shall not be less than 300 cps in draft mode. The printer shall automatically record in English all alarms, troubles, acknowledgements, return to normal, manual commands, plus those automatic commands selected by us user.

r) Alarms shall be highlighted differently than other traffic signals and shall be recorded in English, including type, location, time, date and numerical address of alarm detector. Multiple alarms shall be recorded in the order received, regardless of alarm priority. If an alarm is received during the preparation of reports, the printer shall interrupt the report to record the alarm and afterwards resume the report printing automatically. Automatic (EIP) commands shall be recorded automatically. All changes to system programming shall be recorded automatically.

s) Printer shall use fanfold paper and shall accommodate an original and two copies. Paper shall be tractor fed. Each page shall be automatically timed, dated and numbered to detect unauthorised removal.

t) Printer shall be desktop unit and shall be styled to match the VDU.

u) The printer shall have an indicator to alert the operator that paper has run out.

v) The printer shall have a self-test feature to verify printer operability even when off line.

w) To achieve 100 % redundancy. 2 PCs, VDUs, keyboards and printers shall be provided for communication with the 100% redundant central processing unit of the CFAP, it specified in the data sheets.

x) The central processing unit along with PCs and their peripherals shall be housed in console type enclosure made out of minimum 2 mm thick CRCA sheets.

8.3.5 Fire Detectors and Accessory

Manual Break Glass Type Push Button / Manual Call Point

a) The manual call point shall be of dimensions 100 x 100 mm or more, fabricated out of 2 mm thick cold rolled sheet steel. It shall have weatherproof IP55 construction suitable for outdoor installation.

b) The manual call point shall be break glass type push button and shall have a push button actuator/element kept in pressed condition by the glass sheets fitted on the front of the box. This push button shall be actuated by breaking glass (by means of a wooden hammer provided along with the push button and chained with the push button station) and shall than give an addressable alarm in the alarm panel.

c) The manual call point shall have red epoxy painting and the inscription: “Break Glass in Case of Fire”. Each box shall have distinct identification number boldly painted.

d) All hardware shall be corrosion resistant. All joints and connections shall be made by galvanised / zinc phosphated bolts, nuts and washers secured against loosening.

e) Manual call points / manual break glass type push buttons for microprocessor based fire alarm system shall be addressable type. Each device shall have its own address module, which shall send a status signal to the DGFAP/FAP regarding state of its actuator. The addressable call points shall incorporate a mechanism to interrupt the normal addressable loop scan to provide an alarm response within less than 7 second. The addressable call points shall be field programmable to trigger either an alert or an evacuate response from the control & indicating equipment.

Automatic Fire Detectors

General

All the detectors shall be plug-in-type and shall have twist lock action fitting. A LED shall be incorporated which shall normally flicker indicating alertness and should turn steady when a fire is sensed enabling immediate identification of the affected detector.

The mounting base of all type of detectors shall be identical. It should be possible to plug in any type of detector at any location without changing the base and without disturbing the external wiring. The detector housing shall be damage resistant made of polycarbonate or aluminium with plug-in housing base of universal type suitable for either surface or recess mounting, as stated in the data sheets.

The detector, which has been employed with a Radio Active material the strength of Radio Active material, shall not exceed 1 micro curie.

It shall be possible to loop all type of detectors (manual as well as automatic) in the same fire alarm circuit.

All the detectors shall have inbuilt safety device to monitor the removal and pilferage of the detector.

All detectors shall be suitable for operation at 24V DC, 2 wire system.

All automatic detectors for microprocessor based fire alarm system shall be analogue addressable type. The analogue addressable detectors shall be continuously monitored to measure any change in their sensitivity due to the environment (dir. dust, temperature, humidity etc.) These detectors shall give an advance indication to the fire alarm panel regarding the need for maintenance.

The analogue reading sent by the detectors shall be sensed and if there is a rapid increase an alarm shall be generated. However, if there is a gradual increase in the analogue reading a maintenance alert shall be generated by the DGFAP/FAP.Heat Detectors

a) Heat detectors shall be of electro-pneumatic / bimetallic / thermo electric type, working on the two methods i.e. rate of rise-cum fixed temperature and fixed temperature. The rate of rise- cum fixed temperature element shall have an air chamber, a flexible metal diaphragm and a moisture proof and trouble proof vent, carefully calibrated to ignore any normal fluctuation in temperature, but to respond quickly when the temperature rise is 9° C or more per minute. The fixed temperature feature shall be entirely independent of the rate of rise element and shall be of bimetallic type. The operating temperature of fixed temperature element should be factory set at 57° C +/- 5°C.

Ionisation smoke detector

b) The ionisation smoke detector shall use a dual ionisation chamber in which the air is ionised by a single radioactive source. It shall be complete solid state with LED indicator at base.

c) It shall be capable of detecting visible & invisible combustion gases emanating from fires.

d) The radioactive source used in the detector shall not emit beta & gamma rays & strength of radioactive material shall not be more than 1 micro curie.

e) The detectors shall be designed to have resistance to contamination and corrosion. The detectors shall be suitable for in wind speeds up to 5 m/s. The detectors shall be operation protected against dust accumulation & it shall be free from maintenance & functional tests at intervals.

f) All detector shall be identical in construction, design and characteristics to facilitate easy replacement.

Optical smoke detector

g) The optical smoke detector shall be capable of detecting visible combustion gases emanating from fire. The detector should use forward light-scatter principle using optical components operating at a wavelength of 4.35 mm.

h) The design of the optical smoke detector sensing chamber shall be optimised to minimise the effect of dust deposition over a period of time. The sensitivity of the detector shall be preset by the supplier to suit the site

i) The optical smoke detector shall include RFI screening & feed-through connecting components to minimise the effect of radiated & connected electrical interface

j) The optical smoke detector shall incorporate an LED, clearly visible from the outside to provide indication of alarm actuation.

Response indicator

Response indicator shall be provided in weatherproof box and suitable for mounting on walls, partitions, outside a cabin and below false ceiling and shall be connected to the detector directly. In normal circumstances, the lamp should flicker, but in the event detector inside the cabin senses fire, the lamp should glow steady. Response indicator shall be used in case of non-addressable system.

Exit Signs

Exit signs shall be fabricated out of 2 mm thick cold rolled sheet steel. This shall be suitable for fixing on walls or hanging from false ceiling, Digital Fire Exit / No Fire Exit shall be displayed on both sides of the exit signs. It shall drive power from Fire Alarm Panel and shall operate on DC power supply.

Hooters / Bells

The unit shall consist of solid state circuitry tray on a printed circuit board, a loud speaker and flashing lamp housed in weatherproof dust tight, wall mounted type enclosure. Unit

shall derive power from Fire Alarm Panel and operate on 24 V DC power. In the event of fire, the hooter shall raise pulsating audio alarm and lamp shall flash.

Blinking Lights

Unit shall consist of solid state circuitry on printed circuit board, and a red capped incandescent lamp and audio unit housed in a dust tight, wall ceiling mounted enclosure. It shall derive power from fire alarm panel and operate at 24V DC supply. Blinking lights shall be installed in the enclosed area where suppresser to be dumped. In the event of signal for suppresser release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area.

Fire Suppresser release & inhibit switches

This unit shall consist of pull type suppresser release switch and inhibit switches. The unit shall be fabricated out of 2 mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit suppresser gas.

Sirens

Sirens shall be industrial type of 2.5 km. range(min) against the wind direction. Unless otherwise specified Sirens shall operate at 240V, 1 Ph. AC. Sirens shall be housed in weather proof enclosure

Wiring and Terminals

The panel wiring for power, control, signalling and indicating circuits shall be done with 1.5 sq. mm. PVC insulated copper conductor 650/1100 V grade wires. All wiring shall preferably housed in plastic channels/troughs.

Each wire shall be terminated at a separate terminal. Wherever necessary, shorting strips shall be used for connection between two terminals.

Field contacts will be wired to the panel terminal block with minimum 0.5 sq. mm copper conductor, telecommunication armoured cable. Unless specified otherwise cabling between break glass type push button / manual call point and the central annunciation panel will be in supplier’s scope.

Zener Barrier

Zener barriers, located necessarily in unclassified / non-hazardous areas, may be employed for wiring detectors / break glass boxes installed in hazardous areas. These shall render the circuit beyond the zener barrier intrinsically safe.

Not more than 10 detectors shall be connected to one zener barrier. Zener barriers may be located either in the Zonal panel or DGFAP, if permitted by geographic proximity of detectors and Zonal panel or DGFAP, or may be located close to the detectors / manual call points.

Wherever, zener barriers are provided, in safe area, outside the Zonal panel or DGFAP, they shall be housed in their own enclosure and shall be dust and vermin proof weatherproof with IP-55 degree of protection as a minimum.

Line Isolator

Line Isolator shall be installed, if specified in the enquiry document /datasheets. Line Isolator shall be designed to provide short circuit protection to an analogue addressable detector loop and isolate minimum possible part of the loop. It shall be possible to wire the fault isolator at any point in the detector loop.

The Line Isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

In case the Line Isolator nearest to the fault does not activate first, the isolator shall query other isolators nearest to the short circuit and then de-activate/restore itself.

The DGFAP/FAP panel shall be capable of accessing detectors / devices installed outside the zone covered by the Line isolator modules.

Line isolator module shall be housed in a dust and vermin proof, weather proof enclosure, with IP-55 degree of protection as a minimum

Space Heater

The panel shall be provided with space heater, adjustable thermostat switch and fuse, if called by the atmosphere.

Cabling

EPC contractor shall supply and lay the necessary quantity of appropriate type of cables for interconnections among main fire alarm panel, fire detectors, response indicators, exit signs, hooters, sirens, repeater panel etc as per relevant applicable IS / BS / IEC / DOT standard

All termination of wires shall be carried from bottom of JB's/Electrical panels.

Appropriate glands shall be used at cable openings.

Use of appropriate ferruling for nomenclature.

Earthing

A common earth bus bar of minimum 25 x 3 mm copper or equivalent aluminum shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus bar. All doors and movable parts shall be connected to the earth bus by flexible cables. 2 Nos. earth terminals shall be provided outside the panels.

8.4 Electrical Aspects

8.4.1 Power Supply

A) For the Fire Fighting System, incoming power supply will be made available at single point near starter panel.

415V, 3Φ, 50 Hz, 4 wire, 50 kA solidly earthed system.

B) The equipment shall be designed to operate successfully under the following conditions of voltage and frequency variations:

- Voltage variation not exceeding 10% above or below normal.
- Frequency variation not exceeding 3% above or below normal.

C) The provision of the internal control voltage is the responsibility of the Contractor.

D) Standard Equipment Voltage:

Starter Panel	415V, 3 Ph, 4 wire Grounded
Control Supply	110V DC, 2 wire Grounded
AC Motors	415V AC, 3 phase, 50 Hz
AC Fractional HP Motor	240 V, 1 Phase

Gland plates shall be removable type.

The enclosure shall be dust and vermin-proof and neoprene sponge rubber gaskets shall be provided wherever required. The degree of protection to the internal equipment shall be IP: 54.

Terminal blocks shall be provided for the incoming supply cable, cables from Junction Boxes and other interconnecting control cables. Control terminals shall be 2.5 Sq.mm clip on type. Incoming terminals shall be suitable for 16 sq.mm aluminium conductor cable. 20% additional spare control terminals shall be provided Internal wiring inside the panel shall be carried out with 1100V grade; PVC insulated; copper conductor of adequate sizes.

An earth bar made of aluminium flat of adequate size with 2 Nos. earthing terminals shall be provided. Arrangement shall be made inside the panel for terminating earthing core of control cables on this. Each panel shall be provided with the following:

a) Each control unit provided with an integral power supply unit which supplies 24V DC power from 240 V + 10%, 50 Hz + 5%, 1 Ph AC mains.

a) Faults shall be annunciated with the help of solid state type Annunciator having specified numbers of windows for sub zonal fire annunciation, for cable faults and for battery charger and miscellaneous fault annunciation and minimum four empty windows with provision for adding the required accessories at a later date. The annunciator shall have accept, test and reset push buttons.

8.4.2 Wires & Conduits

Wires shall be 1100 V grade, stranded 1.5 sq.mm copper conductors, and flame retardant low smoke (FRLS) type.

Wires required for interconnection of the various units of the fire detection and alarm system shall be laid inside heavy GI Conduits. Conduits less than 19 mm dia shall not be used. While installing conduits sufficient number of junction boxes shall be provided to facilitate drawing of the wires. Conduits shall be provided with 8 SWG GI wire for earthing.

8.4.3 Junction Boxes

Junction boxes shall be provided with 2.5 sq.mm clip on type terminals. A minimum of 2 numbers spare terminals shall be provided. Cable entries to junction boxes shall be from bottom. Minimum 2 Nos. 3/4" ET entries shall be provided on the junction boxes. Unused entries shall be closed with aluminium plugs. Two Nos. earthing terminals will be provided on the junction box, one inside for internal earthing by one core of control cable.

The junction box shall carry a serial number plate to indicate sub-zone in which it is located.

8.4.4 Grounding

Grounding shall conform to IS: 3043. However, the main earthing grid and pits will be provided by others. Fire alarm panel shall be earthed at 2 points using 25x6 mm. GI strips connected to the plants earthing loop.

8.4.5 Testing

Following tests will be conducted on all equipment's:

i) Operation test.
ii) Insulation resistance tests with 500 V DC megger.
iii) H.V. test at 2.5 kV for 1 minute for power circuit and 1.5 kV for 1 minute for control circuit.
iv) 100 hours burn-in test for fire alarm panel.

8.4.6 Local Control Panel

A) Construction

Sheet steel clad, fabricated out of 2.5 mm thickness CRCA sheet steel. The panels shall have (Lift-Off Type) hinged doors, capable of being opened through 180 deg. A packet shall be provided on panel door for cable termination charts which are also in the purchaser's scope. All doors shall be supplied with built-in locking facility. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.

In case of floor-mounted type, panels shall be supplied complete with foundation and lifting eyebolts along with panel base frames for foundation.

B) Installation

Free standing floor mounting type/wall mounting type.

C) Enclosure Protection

Dust and vermin proof, IP: 54, Indoor type.

D) Painting

The sheet metal parts shall be subjected to the following pre-treatment before final painting:

i) Degreasing
ii) Pickling for complete rust removal
iii) Phosphating
iv.) Corrosion resistant primer painting.

The final outside paint finishing of the panel shall be fire red shade No. 538 as per IS: 5. inside paint of the panel shall have eggshell white colour. Painting shall be epoxy based powder coated and suitable for the specified site conditions.

E) Name Plate

These shall be metallic/non-metallic type. Metallic nameplate shall be coated with clear vinyl paint to prevent corrosion and shall be engraved type. Non-metallic type nameplate shall have white background with engraved black, English and numerical letters. It shall be removable type.

F) Components

Isolators, HRC fuses, contactors, overload and single phase protection relays, control transformer, push buttons, meters and other associated equipment or controls required for the system shall be included.

i) Push Buttons/Control Switches

Push buttons shall be shrouded and spring return type. “STOP” push button shall be mushroom-headed stay-put type lockable in pressed condition.

Local push button station on the berth shall possess IP:65 degree of protection.

ii) Terminal Blocks

As required plus 20 percent spares of each type and rating.

G) Indication Blocks

System fault annunciation and indications for status ON/OFF (at remote) shall be provided.

H) Wiring

Control wiring shall be done by PVC insulated 1.5 sq.mm copper conductor and for CT 2.5 sq.mm copper flexible cable, heat shrinkable sleeve for al. bus bars insulation shall be provided.

I) Earthing

Two earthing terminals shall be provided on each panel and local push button station.

J) Panel Illumination

The interior of each panel shall be illuminated through incandescent lamp operated by a panel door switch. A 240 V LT, 5A, 3 Pin receptacle with ON/OFF switch and fuse unit shall also be provided.

8.4.7 Cables

1.1 kV grade aluminium/copper conductor armoured FRLS cable.

Minimum size of conductor	6 Sq. mm (aluminum) 4 Sq. mm (copper)

8.4.8 Motors

A) Type

The motors shall be squirrel cage induction type.

B) Motor Control/Starting

The motor shall be suitable for Star-Delta start and shall be starter controlled with backed up MCCB and O/L element unless otherwise specified.

The motors shall be capable of starting at minimum 80% of nominal voltage rating with connected load throughout **the whole starting period at rated frequency.**

C) The motor characteristics shall be such that it shall be suitable for continuous running with full load at 75% of voltage for 5 mins. Motors shall not stall due to voltage dip with system causing momentary drop in voltage to 70% of the rated value.

D) Duty, Output and Characteristics

i) The motor shall be suitable for continuous operation at rated capacity. The motor shall be capable of delivering full output at 90% rated voltage within the permissible temperature rise.

ii) Motor shall be capable of:

Two starts in succession with motor initially at a temperature not exceeding the rated load operating temperature. Three equally spread starts in an hour, the motor initially at a temperature not exceeding the rated load operating temperature.

iii) The starting torque of the squirrel cage motors shall be as per system requirement.

The starting current of the motors shall not exceed six (6) times full load current at rated voltage subject to the tolerances given in IS:325. The motor shall have a pull out torque of more than 250% of full load torque.

iv) The starting torque of motor shall be coordinated with the requirement of the driven equipment on the basis of minimum voltage of 80% rated voltage at motor terminals. There shall be sufficient margin of motor torque over the torque requirement to obtain proper accelerating torque so that the starting time is minimized.

v) For motors with starting time upto and including 45 seconds at minimum permissible voltage of 80% rated voltage (at start), the locked rotor withstand time (hot) at rated voltage shall be at least 5 (five) seconds more than the starting time.

vi) For motors with starting time more than 45 seconds at minimum permissible voltage of 80% rated voltage (at start), the locked rotor withstand time (hot) at rated voltage shall be at least 10 (ten) seconds more than the starting time.

The motors shall be designed to withstand 120% of rated speed for 2 minutes without mechanical damage.

E) The noise level shall conform to the requirements of IS:12065.

F) The amplitude of vibration shall be within the limits specified in IS:12075.

G) Enclosure Protection

Motors shall have totally enclosed fan cooled enclosures for operation in humid and dusty atmosphere. Motors shall have degree of enclosure protection IP: 54 for indoor and IP:55 for outdoor use as per ISS:4691.

H) Class of Insulation

Motors shall have class 'F' insulation with permissible temperature rise max. 75^0 C over 45^0 C by resistance.

I) Winding Protection

Motors rated 75 kW and above shall be fitted with thermisters for winding protection.

J) Winding Connection

Stator windings shall be delta connected.

Motor winding leads shall be brought out through seal off "bushings". Cable shall not be used for connecting the windings to the terminal boxes.

For motors above 75 kW both the winding leads of each phase shall be brought out to the terminal box with necessary shorting links for achieving desired winding connections at site.

K) Bearing

All motor shall be provided with adequate grease lubricated ball or roller bearings as required to ensure reliable operation. The bearings shall be housed in dust-tight bearing end shields and shall be provided with easily accessible grease nipples and valves for ejecting excess grease.

L) Space Heater

All motors rated 30 kW and above shall be provided with space heaters to maintain the motor internal air temperature above dew point. Space heaters shall be suitable for a supply of 240 V AC, single phase, 50 Hz. Motors rated below 30 kW shall be suitable for connecting 24V, AC supply to its stator winding for winding heating during idle time.

Separate terminal boxes shall be provided for space heaters.

M) Terminal Boxes

All motors shall be provided with cable termination boxes with removable gland plates, without any drilling, suitable for terminating cables and required quantity of double compression GI glands.

An additional adopter box to the motor terminal box shall be provided if required to facilitate cable terminations. The size of the adopter box shall be decided based on cable size and number of cables to be terminated. The box shall be good quality and fabricated out of 2 mm thick MS steel, properly painted and gasketed.

Each terminal box shall be fitted with earthing screw of suitable size on one end. Unless otherwise approved, the terminal boxes shall be capable of being turned through 360 deg. In steps of 90 deg. Unless otherwise specified, the position for the main terminal box will be on the right hand side as seen from drive end of the motor.

N) Cooling and Cooling Fans

The motor shall be in general fan cooled type having the fans as integral parts of the motors themselves.

The cooling fans for each motor shall be of such design that the motors can turn in any direction without/with minor medication at site.

O) Name-plate Marking

At least the following information shall be shown on motor name plate:

a) Manufacturer's Name

b) Type

c) Manufacturer's Serial Number and Frame Reference

d) No. of Phases and Phase Connection

e) Rated Voltage

f) Rated Current

g) Rated Power output in kW/HP

h) Rated Load Power Factor

i) Rating Speed

j) Rating Frequency

k) Class of Insulation and Temperature Rise

l) Bearing identification numbers (in case of ball/roller bearing and recommended lubricant).

m) In addition to the manufacturers standard name plates, a metal tag for motor identification number (6 digit, 12 mm high) shall be fixed to each motor

P) Painting

All ferrous surfaces shall be subjected to the following pre-treatment before final painting:

a) Degreasing

b) Pickling for complete rust removal

c) Phosphating

d) Corrosion resistant primer painting.

The paint shall be epoxy based and shall be suitable for withstanding specified site conditions. All fasteners used in the construction of the equipment shall be corrosion resistant against salinity. Unless otherwise specified, the colour of finish paint shall be light grey shade No. 631 as per IS:5

Q) Accessories

Two separate earthing terminations shall be provided.

All motors shall be equipped with suitable lifting arrangements or lugs.

R) Specified Tests

a) All motor shall be routine tested as per latest relevant ISS.

b) The type test certificate of tests conducted on identical motors shall be furnished.

8.4.9 Make of Components

Make of the individual mounted equipment shall be selected as per the following list. Employer, however, reserve the right to select the particular make during detailed engineering for uniform design and in view of Employer's spares inventory.

Item	**Make**
A.C. Power Contactor	Siemens/L&T/BCH/Schneider Electric
Auxiliary Contactors/Relays	L&T/Siemens/Schneider Electric
Fuse/Link	Alstom/Siemens/L&T/Schneider Electric
Indicating Lamps (LED Type)	L&T/Siemens/Alstom/ Schneider Electric
Push Buttons	L&T/Siemens/ Schneider Electric
MCB	L&T/ Schneider/Siemens/GE Controls
Cables	CCI/Universal/National/Asian/ NICCO/Lapp/Skytone
AC Motors (415V)	Siemens/ABB/ Crompton/ Marathon Electric
Terminal block	Elmex/Connectwell

9 DRAWINGS

9.1 List of Drawings

S. NO.	DWG. NO.	TITLE
1	I-525/KGT/1001	LAYOUT PLsAN OF TERMINAL
2	I-525/KGT/1002	TOPOGRAPHY SURVEY
3	I-525/KGT/1003	HYDROGRAPHIC SURVEY
4	I-525/KGT/1004	LOCATION PLAN OF BOREHOLES.
5	I-525/KGT/1005	GENERAL ARRANGEMENT OF JETTY & APPROACH TRESTLE
6	I-525/KGT/1006	CROSS SECTION OF JETTY & APPROACH TRESTLE
7	I-525/KGT/1007	TYPICAL DETAIL OF BANK PROTECTION WORK
8	I-525/KGT/1008	TYPICAL DETAILS OF CONTAINER STACK YARD
9	I-525/KGT/1009	TYPICAL LAYOUT OF TERMINAL ADMINISTRATION BUILDING
10	I-525/KGT/1010	ELEVATION OF TERMINAL ADMINISTRATION BUILDING
11	I-525/KGT/1011	TYPICAL LAYOUT & SECTION OF WORKER'S AMENITY BUILDING
12	I-525/KGT/1012	TYPICAL LAYOUT AND ELEVATION SECURITY OFFICE
13	I-525/KGT/1013	WEIGH BRIDGE CONTROL ROOM WITH TOILET FACILITY
14	I-525/KGT/1014	TOILET BLOCK
15	I-525/KGT/1015	SUB STATION EQUIPMENT LAYOUT
16	I-525/KGT/1016	TYPICAL CROSS SECTION OF ROAD
17	I-525/KGT/1017	LAYOUT OF WATER SUPPLY SYSTEM
18	I-525/KGT/1018	LAYOUT OF STORM WATER SYSTEM
19	I-525/KGT/1019	TYPICAL DETAILS OF GATE COMPLEX
20	I-525/KGT/1020	LAYOUT OF BOUNDARY WALL WITH FENCING
21	I-525/KGT/1021	CROSS SECTIONS OF BOUNDARY WALL WITH FENCING
22	I-525/KGT/1022	CABLE ROUTE LAYOUT
23	I-525/KGT/1023	LAYOUT OF FIRE FIGHTING SYSTEM
24	I-525/KGT/1024	POWER SINGLE LINE DIAGRAM
25	I-525/KGT/1025 (SHT-1)	BERTHING APPURTENANCES DETAILS
26	I-525/KGT/1025 (SHT-2)	BERTHING APPURTENANCES DETAILS
27	I-525/KGT/1025 (SHT-3)	BERTHING APPURTENANCES DETAILS
28	I-525/KGT/1026	LAYOUT & DETAILS OF END BUFFER, JACKING PLATE & STORM ANCHORS
29	I-525/KGT/1027	CONSTRUCTION METHODOLOGY PLAN & CROSS SECTION

Appendix A

Geotechnical Investigation Report

Appendix B

Environmental Management Plan

Appendix C

Form of Performance Guarantee for Anti-Termite Treatment